WASHINGTON NUMBER

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PROF. E. J. SAUNDERS, University of Washington

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The JOURNAL of GEOGRAPHY

A Monthly Magazine Devoted to the Interests of Teachers of Geography in Elementary, Secondary, and Normal Schools.

RAY HUGHES WHITBECK, *Editor* LAWRENCE MARTIN, *Associate Editor*
Of the Department of Geology and Geography at the University of Wisconsin

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THE JOURNAL OF GEOGRAPHY

V. C. FINCH, Business Manager

University of Wisconsin, Madison, Wis.

The JOURNAL of GEOGRAPHY

Volume XIV MAY 1916 Number 9

THE PHYSICAL GEOGRAPHY OF WASHINGTON

By Edwin J. Saunders
Department of Geology, University of Washington

Geography

WASHINGTON is located in the northwest corner of the United States, directly west of the most accessible passes across the northern Rocky Mountains. It is therefore on the natural trade route between the north central states and the Orient. It is also the nearest shipping point to Alaska. Its location, commodious harbors, varied climate, and great natural resources all combine to make the "Evergreen State" an important factor in the future development of the Pacific Coast.

The state is roughly rectangular in form. The greatest length east and west is 360 miles and the greatest width 240 miles. Its total area is 69,127 square miles including 2291 square miles of water surface. It ranks nineteenth in size, exceeding in area the New England states.

Physical Divisions*

Washington includes portions of the five western physiographic divisions of the United States. Named in order from the west coast these are: the Coast Ranges, the Pacific Coast Valleys, the Cascade Mountains, the Lava Plateaus, and the Rocky Mountains. In a journey across the state these features present an everchanging panorama of low-lying plains, rugged mountains surmounted by snow-clad volcanic cones, and broad plateaus deeply trenched by one of the largest rivers of America. The great variation in rainfall, temperature, soil, and vegetation is the result of these diversified physical features.

Cascade Mountains.—The most prominent feature of relief in Washington is the Cascade Range which divides the state climatically as well as physically along a north and south axis into two quite dissimilar sections. This range varies in width from 50 miles at the Columbia River to 125 miles at the British Columbia line. Viewed from any of the higher peaks the general level of the ridges gives the impression of a deeply dissected, slightly undulating plain. The average elevation of the crest is from 5000 to 6500 feet, with many remnants above this level and a number of passes cut to a level of 3500 feet. These passes have been used by the railroads crossing the state. The Columbia River has cut a much lower gap through the mountains and thus

*See physical map on opposite page.

forms a natural boundary between Washington and Oregon. Surmounting the maturely dissected mass of the Cascades are five large volcanic cones, recently built, and now considered extinct.

Mount Rainier, 14,408 feet high, rises about 7000 feet above the surrounding ridges and carries on its furrowed slopes thirteen glaciers radiating from an immense snow cap to the deeply eroded valleys below. To protect its forests and other natural beauties the United States government has set aside the Mt. Rainier National Park. Because of its glaciers, lakes, cascades, canyons, and broad parks of wild flowers it is considered one of the beauty spots of America. The ease with which it is reached from Tacoma or Seattle in a one day trip is making it a very popular resort.

In the northern part of the Cascades, Mt. Baker (10,750 feet), another large volcanic cone, somewhat less rugged than Mt. Rainier, rises 5000 or 6000 feet above the western flanks of the range. Mt. Baker carries seven glaciers, and is easily reached from Bellingham. A short distance south of Mt. Baker but less prominent because nearer the crest of the main range is Glacier Peak (10,436 feet). This can be seen from the Sound as a great white sugar-loaf. It carries several active glaciers radiating from a common snow cap.

Between Mt. Rainier and the Columbia River Mt. Adams (12,307 feet) and Mt. St. Helens (10,000 feet) rise like sentinels from either flank of the Cascade range. Both have small glaciers on their slopes and with Mt. Hood south of the Columbia River have been described as "The Guardians of the Columbia."

The Coast Mountains. The mountains along the coast of Washington are best described as two distinct divisions, the Olympic Mountains north of Grays Harbor and the Coast Ranges of southwestern Washington between the Columbia River and Grays Harbor.

The Olympic Mountains occupy a large triangular area between Grays Harbor and the Juan de Fuca Straits. Viewed from an elevation they suggest an uplifted, maturely dissected peneplain with main axis of uplift running northwest from Hood Canal to Cape Flattery. The general level of the ridges is between 4000 and 5000 feet, but numerous monadnocks above this level are 6000 to 7000 feet high. Rising athwart the path of the prevailing westerly winds they are subject to the heaviest precipitation in the United States. The higher peaks are snow capped and carry smaller glaciers. Their lower slopes are deeply trenched by numerous valleys due to the heavy rainfall. The upper valleys show decided effects of former glaciation. The rocks of the central axis are a complex series of metamorphosed sediments and intrusive igneous rocks. Bordering the mountains is a low plain of river gravels and sand, wider on the southwest side, scarcely showing on the Hood Canal side. The slopes are heavily timbered and the whole wild rugged area is probably the least known of any area in the United States. The central portion has been set aside as a forest reserve and part of it as a national monument.

The Coast ranges of southwestern Washington are a series of low heavily timbered hills irregular in shape and direction. The maximum elevation is about 3000 feet and they form a divide for the short streams draining into Willapa Bay and Grays Harbor on the west and the interior valley on the east.

The Great Pacific Valley. Between the Cascades and Olympics a broad trough-like depression extends across the state. The northern part of the trough is known as Puget Sound Basin. It was built up as a broad plain of glacial gravels and clays, burying an older irregular topography between the foothills of the mountains. Following erosion the north and south valleys in the plain were overdeepened by a later advance of the glaciers, and when the ice receded these valleys were partially submerged to form Puget Sound. The submergence caused the isolation of many of the higher land masses as islands separated by deep channels. The most northerly group of these make the San Juan Archipelago. Some of the islands have since been united to the mainland by river, wave and current work.

The Southern part of the valley is known as the Columbia-Cowlitz valley. It is made up of a number of irregular rock knobs partially buried by river gravels and alluvium.

The Columbia Lava Plateau. East of the Cascade Mountains a large part of the state south of the Columbia and Spokane rivers is composed of lava flows. Where rivers have cut into the plateau it is seen to be made up of a series of lava beds, in some places aggregating 4000 feet in thickness. Immense floods of lava, welling up through numerous fissures, overflowed this part of the state burying all irregularities except a few of the higher ridges and peaks. Slight warping since the flows occurred has caused ridges like the Badger Mountains and Rattlesnake Hills. The Columbia River in its present, and in other temporary courses, has cut immense trenches below the otherwise unbroken surface. Wind work has been effective in many sections in building up numerous small irregularities in the form of low sand dunes and ridges. Due to the low rainfall in this section it was formerly an extensive sage brush desert, except along the streams. The soil however is rich and under irrigation large areas have been reclaimed and have become very productive.

The Blue Mountains. A spur from the Rocky Mountains that was not buried by the lava extends across the southeast corner of the state into Oregon as a broken ridge about 6000 to 7000 feet high. The general elevation is about 4000 feet above the surrounding plateau and on account of increased precipitation, due to their elevation, the surface is deeply scarred by numerous river valleys. The slopes are timbered and because of the contrast in color with the surrounding country this division both in Washington and Oregon has been called the Blue Mountains.

Okanogan Highlands. A northern spur of the Rocky Mountains, extending westward to the Cascade Mountains north of the Columbia and Spokane rivers, is known as the Okanogan Highlands. Although not so

rugged as either the Cascades or Olympics they are 5000 to 6000 feet in elevation. They consist of a series of north and south ridges rounded off by glacial erosion, sloping gently to flat valley floors. Many intrusive granitic rocks are present and deposits of rich mineral ore and good building stone are quite common in the section north of Spokane.

Geological History

The earliest rocks of known age found in the state are Cretaceous, but there is a great series of older rocks of which the definite age has not yet been fully ascertained. These give us a complicated record of sedimentation and volcanic activity. A succession of movements caused the land to be submerged at times and then exposed to erosion in part at least. The sedimentary rocks thus formed were subjected to lava intrusions and flows which greatly changed the nature of the older rocks. These rocks are found in the Olympics, the northern Cascades, and the Okanogan Highlands.

In the early Tertiary or Eocene period there were low-lying land masses where the Cascade and Olympic Mountains are located at present. The erosion of these land masses furnished sediments which were laid down in a large embayment extending from the Columbia River to the San Juan Islands. The rivers drained into large estuaries which later became swampy, and the lowlands about them supported a luxuriant growth of vegetation. A slight submergence caused the preservation of the vegetation and these beds covered by silt formed the coal beds of western Washington. In some sections more than one hundred of these coal beds are known, each one representing a period of vegetable growth near sea level, with intervening periods of submergence and sedimentation. Since their formation, the coal beds, probably laid down in almost horizontal position, have been folded and tilted strongly and are found at all angles.

In central Washington there were large lake basins in which sedimentation and coal formation was taking place. The Roslyn and other coal beds were formed in this way. Flows of basaltic lava varying in thickness up to 3000 or 4000 feet, were interbedded with these Eocene sediments in both sections of the state.

In the middle Tertiary or Miocene period the waters of the western Washington embayment were partially drained to the north and south by uplift, and sedimentation continued in these smaller embayments. Lava floods welling up through numerous fissures covered practically all of eastern Washington south of the Okanogan Highlands, and extended into Idaho and Oregon. This molten mass hardened to form the black basalt so common in the plateau section. That these flows occurred at long intervals is shown by the presence of petrified trees and stumps between the lava beds, meaning a period long enough for large trees to grow on the surface of previous flows. Thin strata of sediments also occur between the beds. The maximum thickness is about 5000 feet, and eight sheets have been counted along the Yakima River.

Some of the higher knobs of the old surface such as Steptoe Butte and the Blue Mountains were not entirely covered. A series of sediments composed of river gravels, volcanic ash, and possibly lake deposits was spread over the lava surface by drainage from the old Cascade Mountains.

A general uplift about the close of the Miocene caused all the embayments and lakes to be drained. The Pacific coast was probably farther west than at present. Active erosion through the upper Tertiary or Pliocene period reduced the whole state to a low, irregular plain or peneplain sloping toward the Pacific Ocean as a great basin drained by the Columbia and other rivers. The closing event of the Pliocene period was the uplift and warping of the peneplained area to form the present Cascade and Coast ranges and the Olympic Mountains. The surface of the lava plateau in eastern Washington was also folded or warped up at this time to form ridges like the Badger Mountains and Rattlesnake Hills. These movements were slow and the rivers were able to maintain their courses across the uplifted ridges. Thus the Columbia cuts through the Cascade Mountains and the Yakima through the folds between Ellensburg and Yakima and Union Gap south of Yakima.

The irregular surface thus elevated to form the present Cascade Mountains has been called the "Cascade or Pliocene Plateau," and the present valleys and ridges are the results of erosion since uplift. The same is true of the Olympic Mountains, and in either case one can easily get an idea of the reconstructed surface from any of the higher peaks. During the uplift, or at the climax of it the volcanic cones already described were built on the surface of the Cascade block. The other peaks of the Cascades and all the higher peaks of the Olympics are remnants of erosion left as monadnocks above the peneplain due to irregularities in resistance of the rocks, and in stream distribution.

Following the uplift at the close of the Tertiary, or during the early Quaternary period the climate gradually changed so that deep snows collected on the mountains and formed extensive glaciers. These mountain glaciers over-deepened the valleys already begun by river erosion and caused the formation of tributary cascades from hanging valleys, many small lakes and steep-walled valleys. From British Columbia a great glacier moved down the Puget Sound trough as far as Tenino. It eroded the surface, rounding off rock knobs in the northern part, and deposited a heavy drift in the southern part of the basin. As it receded heavy deposits of gravel carried by water from the front of the ice formed extensive gravel plains throughout the area. Regular river systems with north and south trunk streams dissected these plains. A second advance of the glacier again filled the Puget Sound basin. It over-deepened the north and south valleys, but obliterated many of the east and west valleys, thus leaving the basins that were later filled by Sound waters. It also shaped many of the irregular ridges over which it passed, leaving the many rounded hills with long north and south axes. A thin veneer of glacial till was left on the slopes and tops of many of the gravel hills as seen in street cuts about Seattle, and the cliffs along the Sound. As

the last ice receded many temporary lakes were formed in which delta deposits, from the lateral streams and from the ice itself, were built and are now seen as regularly stratified deposits of assorted materials among the unassorted glacial deposits.

In the Mountains, after deepening the valleys and truncating the spurs, the glaciers in many cases left debris barriers in the lower ends of the valleys. Many of the larger lakes were formed behind such barriers and serve as reservoirs for water supply. The tributary streams cascade into the over-deepened main valleys and thus furnish excellent power sites. Glacial work in Washington is therefore an important factor in the economic development of the state's industries.

When the ice finally receded beyond the Juan de Fuca Strait, ocean waters filled the deepened valleys to form Puget Sound, the greatest deep-water inland harbor in the world. Rivers from the mountains have cut deep valleys through the glacial deposits and with their heavy loads of silt have filled in large areas of the sound connecting former island masses to the mainland and considerably increasing the agricultural lands of western Washington.

Drainage

The entire drainage of the state passes finally to the Pacific Ocean from three large drainage areas. These are the Columbia River basin, the Puget Sound basin, and the Coastal belt or Pacific basin.

The Columbia River basin includes all of Washington east of the summit of the Cascade range, and a large area in southwestern Washington as well as the greater part of Oregon and Idaho. The Columbia River, winding its way from the northeast to the southwest corner of the state, has cut a gorge-like canyon through the lava plateau. Even through the Cascade Mountains it was able to maintain its course during uplift and the canyon thus cut is notable for its magnificent scenery. A boat trip from Portland up the river shows one the steep walls of basaltic rock rising 2000 to 4000 feet above the river. Small tributary streams cascade down these steep rock walls to join the boiling torrent, still busy cutting its way through the gorge. Canals at the Cascades and Dalles enable steamers to pass the worst rapids and make the river navigable to Priest Rapids 400 miles from the mouth. Numerous rapids below Wenatchee make continuous navigation here impossible, but above Wenatchee the river is navigable some distance beyond the mouth of the Okanogan River. A striking feature along the river, where it is not in a deep canyon, is the gravel terraces at different levels, continuous for long distances. Below the canyon through the Cascade range low-lying lands and broad swampy flood-plains border the river until the Coast range is reached where high rock hills rise directly from the wide estuary caused by drowning of the river mouth. An interesting event in the history of the Columbia River left its mark in eastern Washington. At the time of glaciation the Okanogan glacier from the north filled the upper Columbia valley at the "Big Bend" and the river diverted from its regular course cut deep gorges across

the lava plateau. Cataracts larger than Niagara Falls existed in these canyons and many deep pot-holes and basins were eroded in their beds. There may have been subsequent glaciation along these valleys. Many lakes, most of them with no outlets, and therefore mineral or alkaline, still occupy these depressions in the old valleys which are known as "Coulees;" Grand Coulee, Moses Coulee, Crab Creek, etc.

The eastern tributaries of the Columbia are few in number but among them is the Snake River, the largest of all, and some of them are very important on account of their use for water power. The Pend Oreille or Clarke Fork, and the Colville River flow through broad fertile valleys in the north. Spokane River flows in a broad valley, an old valley train filling of gravel, until it reaches Spokane where, cutting through the gravel filling, it has come upon a hard ledge of rock over which it falls in a series of cascades. These yield abundant power for the whole "Inland Empire." Below the city it flows in a deep canyon between high terraces, with occasional rapids some of which are used for power. Of a possible 230,000 horse power about 45,000 horse power is developed. About the upper falls the city of Spokane has grown.

The Snake River enters the state near the southeast corner and flows in a deep canyon through the lava plateau. It is navigable from its mouth to the state boundary and by the removal of a few protruding rock ledges may be made navigable for many miles in Idaho. Falls higher up in its course furnish much water power.

Many large tributaries from the Okanogan Highlands and the Cascade Mountains enter the Columbia from the north and west. Abundant precipitation in the mountains and numerous lakes and snowfields give these tributaries a fairly uniform supply. The Okanogan River is the largest of three rivers flowing in almost parallel valleys from the north. It is navigable for some distance except in extremely low water and is bordered by a wide fertile valley. One of the latest government irrigation projects is located in this valley and will make usable a large acreage of otherwise unused land. The other rivers in this section are the Methow, and the San Poil.

Lake Chelan, lying between high mountains of granite, is held about 400 feet above the Columbia River by a barrier of morainal drift in the lower end of an old river valley. Its surface is about 1100 feet above sea level and the glaciers have gouged the valley to a depth of 400 feet below sea level making the lake about 1500 feet deep. It is about 50 miles long and only 2 miles in width. Nestled in the mountains it is one of the many scenic spots in Washington. Chelan falls at the lower end of the lake and Stekekin falls at the upper end of the valley add to the beauty as well as to the available power in this section.

The Wenatchee River with a natural reservoir in Lake Wenatchee has eroded a low grade valley into the very heart of the Cascade Mountains. The Great Northern railroad follows this valley as far as Leavenworth where it

begins its steep ascent to the Cascade tunnel. Several power plants are located along the river.

The Yakima River is the largest eastward flowing tributary of the Columbia. Three large lakes, Keechelus, Kachess, and Clealum formed behind morainal barriers in almost parallel glacial valleys serve as reservoirs. The capacity of each of these basins has been increased by dams to furnish water for the irrigation of thousands of acres of fertile land lying along the Yakima valley. The river flows through deep canyons where the lava plateau has been arched up across its path and through broad open valleys where softer rocks have permitted more mature erosion. The orchard lands are even more extensive than along the Wenatchee Valley, and large shipments of fruit are made every year. Many power plants along the main stream and its tributaries furnish electricity for local use. At Clealum the Roslyn-Clealum coal field is exposed by erosion. The Northern Pacific and the Chicago, Milwaukee & St. Paul railroads use the low grade valley, entirely, and in part, for their route across this section into the Cascade Mountains.

The Puget Sound Drainage basin includes rivers from the western slopes of the Cascades and those from the eastern and northern slopes of the Olympics. Their valleys have been strongly glaciated and they flow from short steep valleys with many falls and rapids well adapted for power sites. Many power plants have already been installed but only a small fraction of the available power is used.

The Skagit River has the largest drainage basin and has formed the largest alluvial deposits. The delta of the Skagit or the La Conner flats and the flats for miles along the valley furnish the largest and best area of agricultural land in western Washington. The river is navigable for sixty miles through this broad flat.

The Cedar, Green, White and Puyallup rivers have combined in filling up what was formerly part of the Sound behind the high land area which has been called "Des Moines Island." In so doing part of the Sound was shut off to form Lake Washington, and the broad fertile Duwamish-Puyallup valley was left to supply Seattle and Tacoma with their garden truck. The streams draining the north and east slopes of the Olympics are short and swift affording many excellent power sites.

The Pacific drainage includes many minor streams along the western border of the state from Cape Flattery to Columbia River. The important streams on the Olympic Peninsula are the Soleduck, Hoh, Oueets and Ouenlult. These drain the heavily timbered slopes of the Olympics and may some day be important in facilitating the handling of the timber of this extensive area.

Lakes

Numerous lakes have been formed in the Olympic, Cascade and Okanogan Mountains by glacial erosion and deposition. These are in the form of

very small rock rimmed lakes in glacial cirques or in long, trough-like valleys. The glaciers at one time filled these valleys and built across them morainal deposits behind which the waters have since collected to form lakes. Many lakes irregular in size and shape are found among the uneven glacial deposits about Puget Sound and along the Straits. Among these are Crescent, Whatcom, Sammamish, Union, and Washington. Lake Queniult and Ozette are in the valleys of the same name at the foot of the western slopes of the Olympics. Queniult although 35 miles from the ocean is only 300 feet in elevation and Ozette only 50 feet above sea level. In central Washington numerous lakes are found in old abandoned stream channels and in small basins formed by wind blown sand. Many of these on account of low precipitation and lack of outlet are intermittent or if permanent are strongly mineral.

Coast Lines

Four great embayments, due to the submergence of a deeply eroded land mass, provide Washington with more than 2000 miles of shore line. This does not include the Columbia River, now navigable throughout its entire length along the southern border of the state.

Puget Sound, formerly applied only to the southern portion of the vast inland sea, now includes all American waters in this section. The total area is over 2000 square miles and on account of the numerous indentations and islands formed by submergence, its shoreline is about 1700 miles. It reaches a maximum depth of 900 feet, is deep close into the shore in many places and practically free from shoals. The southern end is protected from strong winds and is therefore an excellent harbor. Cliffs in the glacial drift form the greater part of the shore, but large river deltas and river flats extend for miles in some sections. Sandspits and bars formed by waves and shore currents have been effective in connecting former islands with the mainland and in a few cases enclosing fairly good harbors, as at Port Angeles and Dungeness.

The rivers along the Pacific coast have all been subject to submergence but in only three of them has this resulted in an embayment which can be used as a harbor. Either the stage of erosion was not far enough advanced when submergence occurred or a slight elevation since submergence, together with river filling, has obliterated any embayments that were formed. Grays Harbor, Willapa Bay, and the Columbia Estuary have been partially separated from the ocean by long sand spits or bars built by shore currents, thus shutting off as good harbors what would otherwise have been broad bays open to the severity of the ocean storms. It has been necessary to build jetties at Columbia River and Grays Harbor to keep the bar from entirely closing the harbors to navigation.

With these unexcelled harbors and opportunities for shipping, the development of Alaskan and Oriental trade, and the opening of the Panama Canal, are of great importance to the coast cities and to the state as a whole.

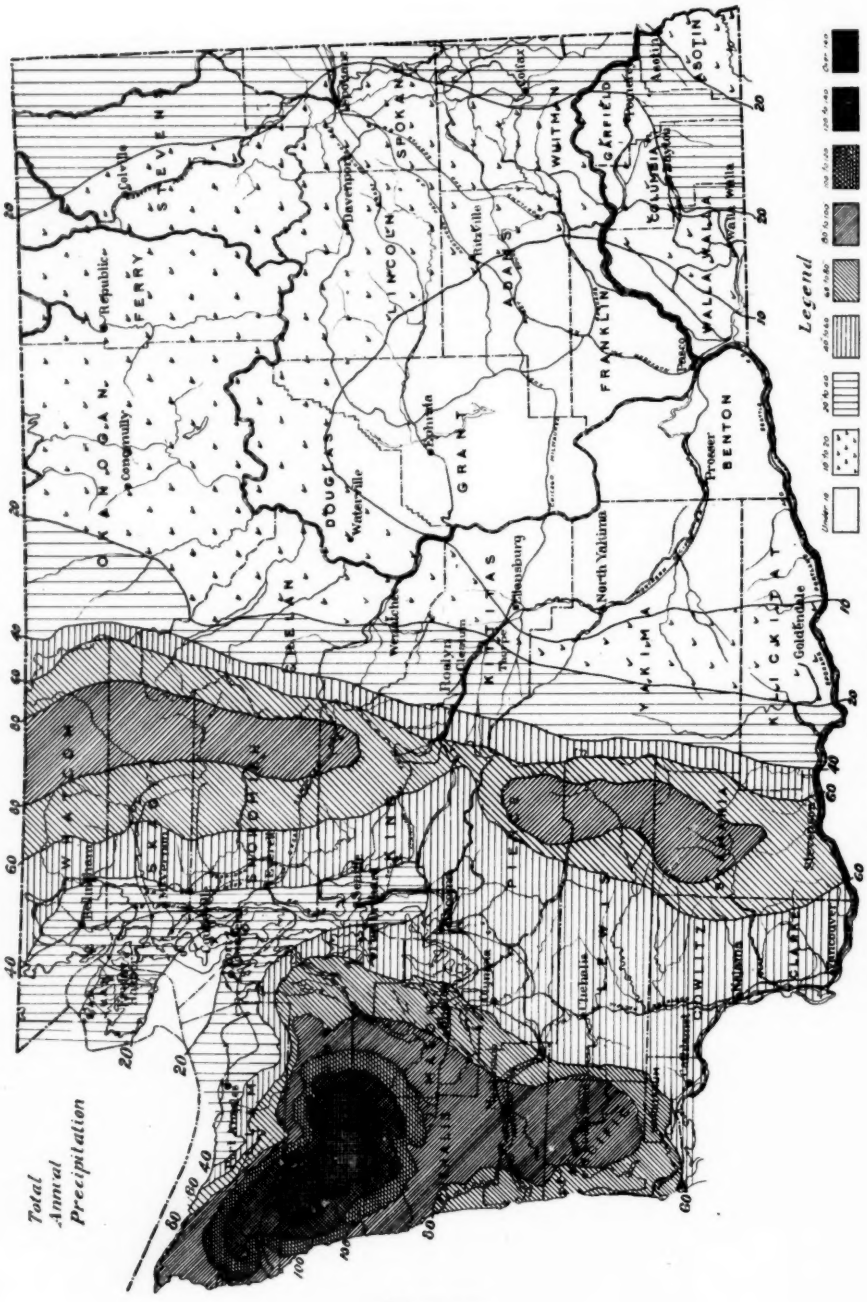

Fig. 1. Map showing distribution of Rainfall in Washington.

CLIMATE

The location of the state on the eastern shore of a great ocean, in the path of the prevailing westerly winds and the accompanying succession of cyclones and anticyclones in their general course from west to east, causes the climate

in general to be more equable in temperature than other states in the same latitude. But on account of the great variations in altitude and the north-south trend of the physical divisions, no other state in the Union shows greater diversity in climatic conditions. The western lowlands, exposed directly to the moist ocean winds have a marine climate, moist and warm in the winter, dry and cool in the summer. The eastern section, because of the Cascade barrier which partially shuts out the oceanic influence, has much colder winters, warmer summers, and less rainfall than the coastal belt, thus approaching continental conditions, although somewhat protected from prolonged periods of extremes in temperature by the mountains north and east of the area. The higher mountain masses show all the peculiarities of high latitude climates with perpetual snow, glaciers, lower temperatures, and greater precipitation.

Precipitation. From the variation in total annual precipitation, the state may be divided into several rainfall belts following the general trend of the major physical divisions. (Fig. 1.) A large area along the Pacific Coast has an annual rainfall of over 60 inches and is known as the "Coastal wet belt." The warm moisture-laden winds moving inland are forced to ascend the slopes along the coast and in some parts of the Olympic Mountains the rainfall is over 140 inches, the greatest in the United States.

Farther inland there is a gradual decrease in rainfall, but when the moist air is forced to ascend the western slopes of the Cascades a second belt with rainfall exceeding 60 inches is the result. This belt extends over the summit of the mountains and at many points the rainfall probably exceeds 100 inches. It has been called the "Cascade wet belt."

Between these two wet belts, in the Puget Sound basin the annual rainfall varies from 60 to 20 inches. The low summer rainfall makes irrigation necessary for the best results in growing fruits and garden truck. This belt is known as the "moist belt." The decrease in precipitation as the air moves inland through the Grays Harbor lowland is remarkable. Aberdeen has a total rainfall of 85.57 inches, Olympia 54.96 inches, Tacoma 42.26 inches, Seattle 34.36 inches, and Port Townsend 20.68 inches. The difference along the Straits of Juan de Fuca is also striking with Tatoosh and Neah Bay 84.43 inches, Port Crescent 42.05 inches, Port Angeles 29.81 inches, and Port Townsend 20.68 inches.

As the air moves down the eastern slopes of the Cascade range and out over the Columbia River basin the rainfall rapidly decreases to less than 20 inches. The air has lost its moisture and being dynamically warmed is able to take up moisture and therefore causes scant precipitation and clear skies. There is a narrow belt at higher altitudes with rainfall between 60 and 20 inches known as the "Cascade moist belt," or a transition belt between the heavy summit and the low interior precipitation.

The whole central portion of the state has less than 20 inches of rainfall and a large area in this "dry belt" has less than 10 inches a year and may be called the "arid belt." The rapid decrease in rainfall is well shown in the

stations along the Northern Pacific railway: Martin 80 inches, Clealum 25.91 inches, Ellenburg 9.79 inches, North Yakima 8.67 inches, Kennewick 6.34 inches.

A third belt in which rainfall is above 20 inches is found along the eastern border of the state. With increasing elevation the rainfall increases and the Blue Mountains and Okanogan Highlands are included in the "eastern moist belt."

In those sections where the precipitation is above 20 inches is found the growth of timber that has made Washington the foremost lumber state. In some sections of central Washington dry farming has been very successful, but in the arid belt which was formerly a sage-brush desert little farming can be carried on successfully without irrigation.

Washington as a whole has a wet winter season and a dry summer season but the distribution throughout the year in different sections varies considerably. In western Washington between 70 and 75 per cent of the total precipitation occurs in six months and from 85 to 90 per cent in eight months, October to May inclusive. Of the remaining four months July and August have very low rainfall, less than 1 inch each. The number of days with rain will be between 130 and 200 with 100 to 150 clear days. In eastern Washington little more than half the annual precipitation occurs in six months, and there is more rain in May and June than in the other dry season months. The average number of days with rain in this section is 40 to 70 and the clear days 150 to 220.

The winter maximum of precipitation is accounted for by the numerous cyclonic storms of that season and by the rapid condensation of moisture in the air as it blows over a cold land from the ocean and usually from south to north. In summer the storms are less numerous and intense and the winds from the ocean and northerly quarter are blowing over warmer lands. The slight summer maximum in central Washington is explained by the occurrence of convectional storms typical of the summer season in interior states.

Snowfall. The snowfall varies from 10 inches annually for the coast and the lower central stations to over 100 inches for the mountain stations, and as high as 572 inches or about 48 feet has fallen at certain stations during one winter season. The average for a number of sections is as follows: Coast stations 9-10 inches, Puget Sound 13 inches, Western slope of Cascades 60 to 70 inches, Mountain stations over 100 inches, Sunnyside 8 inches, Wenatchee 70 inches, Spokane 38 inches. The length of time that the snow remains on the ground varies from a day or so for coast stations to 10 or even 12 months for some points along the summit of the Olympics and Cascades. This is significant in the river supply from melting snows, the high water of snow supply coming along in late summer when the precipitation is low. The snow remains longer in eastern Washington where most needed to protect vegetation from the cold spells and heavy freezes which are more common in that section.

Humidity. Full records for the relative humidity are not obtainable but the readings from Seattle and Spokane will illustrate the difference between the two sections of the state. Sound stations show an average humidity of 83 per cent, decreasing from 89 per cent at 5 a. m. to 77 per cent at 5 p. m. Spokane shows a mean annual humidity of 65.3 per cent and stations along the Columbia such as Kennewick would probably be still lower.

Temperature. The variation in temperature conditions in different sections of the state is just as striking as the variation in precipitation. Due to the oceanic influence western Washington has only moderate changes in temperature. The high humidity of the air, the southwesterly winds in winter and northwesterly winds in summer, the rapid condensation of moisture in this section during the winter months, and the protection from the easterly winds, cold in winter, warm in summer, by the Cascade Mountains all combine with the ocean winds to cause low daily, monthly and annual ranges of temperature. Frequently for several days in the winter the temperature will not vary more than 5° but in the warmer summer days it will vary as much as 30° to 40°. The average annual range of temperature for the coast stations is about 20°; for Puget Sound stations about 24°, or from 38° to 62°; and for Cascade stations about 30°, or from 33° to 63°. Cold spells are infrequent, and only at long intervals does the temperature go as low as zero. The lowest temperature recorded is —8° at Vancouver. Hot spells in summer are also rare and, although 105° has been recorded, temperatures above 90° have been recorded at Seattle only 16 times in the past 21 years. The nights are usually cool even during the hot spells.

Eastern Washington, shut off from the warm moist ocean winds by the Cascade Range and lacking its protection from the easterly winds, is more subject to continental extremes of temperature. The mountains of British Columbia and the Rocky Mountains furnish a slight protection, however, from the interior influences, and the extremes of temperature are not therefore so frequent nor of such long duration as in the states farther inland. The average annual range is between 40° and 50° with winter temperatures about 20° to 30° and summer temperatures from 65° to 80°. The extreme range for any one station is 140°, but temperatures as low as —36° and as high as 115° have been recorded at different stations. Temperatures as low as —20° and as high as 100° are common, but the cold and warm spells are of short duration and are not felt as much as the figures might indicate on account of the low humidity of the air.

Growing season. As a result of the strong oceanic influence, the frequent southerly winds, and the consequent cloudy skies which prevent nocturnal radiation in the spring and fall, the growing season or the time between killing frosts in western Washington is much longer than in eastern Washington where clear skies prevail. The average season between the last killing frost in spring and the first in the fall for Puget Sound is about 200 days, from April 15 to November 1. For some of the stations this period is 250 days. In eastern Washington only 120 to 170 days are apt to be free

from killing frost, or from about May 1 to October 1. The occurrence of these late and early frosts is quite irregular however, as they may occur very late or early if a well developed anticyclonic area passes over the state. The stronger insolation partially compensates for the shorter growing season in eastern Washington, as there are a greater number of bright days. In the mountain sections frosts are apt to occur at any time during the summer especially if the air is clear and dry.

Winds. The prevailing direction of the wind is from the west but local topography and the passage of storms cause modifications in direction for different stations and at different times. The usual track of the low pressure areas is so far north in the state or beyond the British Columbia boundary that the winds, especially in the winter, are from the south and therefore warm. This also causes the cloudy, rainy weather so prevalent in the winter months. If the storms move farther south, northerly winds prevail, the weather is clear, and if a high pressure is well developed northeast of the state we get a spell of clear cold weather in winter, but northerly and easterly winds are not common.

In the summer months the storm centres are not well defined as they move over the state, and the high pressure over the Pacific Ocean causes strong westerly and northwesterly winds with clear sky and cool nights. The strongest winds ever recorded are between 50 and 60 miles an hour and tornado-like storms are practically unknown. Few thunderstorms occur in western Washington, and only occasional mountain thunderstorms in eastern Washington. The winds in winter are much stronger than in summer due to better development of the regular cyclonic areas as they come in from the Pacific Ocean or down the Alaskan Coast.

A warm, rain-producing wind from the southwest in western Washington is called the chinook. But it is on the eastern slope of the Cascade range that we find the typical chinook or foehn wind. The air in passing over the mountains has been deprived of its moisture content and in descending the eastern slope is dynamically warmed by increased pressure and blows over the Columbia Basin as a warm, dry wind, in winter often causing the rapid melting and evaporation of snow.

Mountain and valley winds are also common in all the larger valleys as the cold air at night drains to lower levels and the air during the warm afternoons flows upward along the slopes.

Summary. We thus have in Washington three general types of climate: (1) oceanic or marine with slight range in temperature and a decided winter maximum of precipitation; (2) continental with extremes of temperature slightly modified by proximity to the coast, and a slight summer maximum of rainfall in addition to the regular winter maximum of marine climate; and (3) mountain climate with cloudy, rainy windward and dry leeward slopes, and strong winds caused by irregular heating and cooling. The Japan current has little effect except in a very general way by causing slightly higher temperatures to prevail in the whole northern Pacific Ocean.

THE WATER RESOURCES OF WASHINGTON

By Henry Landes
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Precipitation

THE State of Washington is located in the path of the prevailing westerly winds. Since these blow off the Pacific Ocean, at temperatures conducive to ready evaporation, it is not surprising that they are generally high in humidity when they reach our western shore. In crossing the state they pass over a great variety of topography so that belts of fog, rain, snow, and sunshine are commonly produced. The zones or belts of fog and rain are common to the western slopes of the mountains and the areas of snow-fall to their summits; while at the eastern bases of the highland masses the air clears and sunshine is the rule.

Storage

In order to receive the greatest benefit from the normal precipitation of a region natural means of storage must be convenient. Precipitation is generally seasonal or irregular and hence any method of storage at hand will assist in preventing floods and make the run-off of the streams much more regular. In regions of moderate rainfall it is of great value to a country to be served by streams that are active all the year.

Proceeding from within outward we find the chief reservoirs or storage facilities in the rocks, soils, lakes and swamps, snowfields and glaciers. It is a well known fact that sedimentary rocks in general hold more ground water than igneous and metamorphic rocks. Of sedimentary rocks sandstone has the largest pore space and hence is the most frequent container of water stored in the bed-rock. In Washington igneous and metamorphic rocks predominate and sedimentary rocks underlie only a minor portion of the state. East of the summit line of the Cascades sedimentary areas are relatively small and disconnected. They are composed mainly of sandstones and shales of lacustrine origin and of Tertiary age. West of the Cascades sedimentary rocks occur over considerable areas in the foot-hills of those mountains, as a narrow fringe around the Olympics, and in larger areas in the southwestern counties facing the lower Columbia and the ocean. The main western slope of the Cascades is composed of metamorphic rocks with igneous flows and intrusions; the core of the Olympics is a mass of closely folded metamorphics; and basalts alternate in outcrop with sandstones and shales in southwestern Washington.

From the above statement it will be seen that the bed-rock of the state as a whole is not favorable for the maximum storage of water. The only localities where it is necessary to draw upon the bed-rock for water supplies is in the more arid portions of eastern Washington where surface storage is in-

sufficient to meet the needs of the people. In the Yakima Valley, where beds of sandstone and shale have been locally folded into synclinal basins, flowing wells are obtained which are used for domestic supply as well as for irrigation. Throughout the extensive basalt plains of south-eastern Washington, embracing almost one-third of the state, with an annual rainfall from five to twenty inches, wells of excellent water are obtained at depths varying from 100 to 500 feet. In penetrating the basalt the water is found sometimes in the very porous layers where an abundance of steam-holes characterize the rock, and at other times from the strata of sand and gravel that are sandwiched between two successive flows of lava.

The mantle of soil in Washington is very general, the principal exception being the precipitous mountains from which the disintegrated rock is swept away as rapidly as it is formed. Over large areas of the state the soil is abnormally thick. That is particularly true of the extensive areas of eolian soils in the south-eastern part of the state and of the glacial deposits about Puget Sound. On the whole the soil covering is a great reservoir for water storage, except where desert conditions prevail or where the soil is too thin to serve as a sponge. The unusual amount of water retained in the soil is demonstrated by the innumerable springs which are characteristic of the state. The varying amount of water contained in the soil is reflected very generally by the character of the vegetation in any locality. Where forests grow an intimate relation exists between the kinds or families of trees which predominate over any area and the amount of water stored up in the soil beneath.

Lakes and marshes abound throughout the glaciated portions of the state as well as on the flood plains of the larger rivers. Their total area is large and they are important reservoirs that equalize the flow of the streams. The high mountain lakes are usually in cirques or behind dams of morainal origin. The largest lake in the state, Lake Chelan, is essentially of the same origin as a fiord, in that the long continued rasping of a glacier has worn down the floor of a sinuous and narrow trough until it eventually produced a lake with a maximum depth of 1500 feet. Some of the mountain lakes are due to volcanic action, either where lakes now occupy former craters, or where a lava flow has crossed a main valley at right angles and served as a dam to impound the waters. Many of the lakes in east-central Washington owe their origin to the action of the winds in carrying fine soil and depositing it across the channels of streams at a more rapid rate than the running water could remove the obstructions. Moses Lake has been formed behind a belt of traveling sand dunes which are slowly moving from west to east. Lake Washington, near Seattle was once an arm of Puget Sound, but was severed from it by the building of a delta, followed by a slight elevation above sea-level.

In an unusual degree the snow-fields and glaciers of the state serve as important reservoirs. The snowfall of the higher mountains, especially the Cascades, is excessive. Over hundreds of square miles the ground is bare only

for a month or so in the late summer. The glaciers represent masses of snow and ice of large storage capacity. The five large volcanoes of the Cascades are the centers of radiating systems of glaciers. The crest of that range, especially to the northward, is capped by a chain of glaciers over 300 in number. In the Olympics there are about 50 glaciers, as well as extensive snow-fields. The streams which head in the snow-fields, and especially the glaciers, are characterized by a uniformity of flow, and particularly by a strong summer flow when other streams are at their lowest ebb or have failed entirely.

The Drainage of Washington is discussed on page 314.

Run-off

There is a great variation in the run-off of the streams of the state, not only geographically but seasonally. In the regions of least rainfall intermittent streams are the rule, but in the localities of maximum precipitation they are extremely rare, being confined to the smallest head-waters. Throughout western Washington, numerous live streams are abundant. It is only in the lower plateau or plains portion of the eastern part of the state that active streams are limited in number, and where they sometimes do not occur over considerable areas.

Because of seasonal influences there is much variability in run-off in all the streams of the state. In western Washington the rivers have a minimum flow in August and September because of the slight rainfall of those months. There is an exception to this statement in the case of rivers which head in large snow-fields or among important glaciers. Under such circumstances a uniformity of run-off is secured because of a more rapid melting of the snow and ice during the warm summer months. In western Washington, whenever the snowfall is unusual, the run-off in the late autumn and early spring may cause notable floods. If there has been an early snowfall of considerable depth "November floods" are usually expected. If the snowfall of midwinter is excessive the streams are likely to be swollen when the rapid melting of March and April takes place.

In the arid and semi-arid areas the majority of the streams are active only during the months of spring and early summer. Over much of this region the precipitation is mainly in the form of snow. If the ground be not frozen, and the snow melts slowly, the water may enter the ground, reappear in part as springs, and give a small but rather steady run-off to the streams. If the ground be frozen, and the warmth of spring comes quite rapidly, the snow will melt so quickly that floods along the larger stream courses are inevitable. Such floods are usually of short duration, but they may be quite disastrous when at their maximum.

SUMMARY OF DISCHARGE RECORDS OF CERTAIN RIVERS OF WASHINGTON

River and Locality	Years Observed	Drainage area in sq. miles	Discharge in second-feet				Run-off	
			Maximum Day	Minimum Day	Mean	Mean per sq. mile	Depth in inches on drainage area	Yearly average in acre-feet
Columbia—The Dalles	35	237,000	1,160,000	41,900	216,000	.91	12.22	139,000,000
Snake—Mouth	3	109,000	289,000	14,000	65,200	.59	8.11	47,200,000
Pend Oreille—Newport	8	24,000	155,000	5,700	26,100	1.09	14.79	17,500,000
Skagit—Sedro Woolley	6	2,930	96,100	3,250	15,000	5.11	69.20	10,900,000
Spokane—Spokane	22	4,000	35,200	1,240	8,330	2.08	28.24	6,040,000
Yakima—N. Yakima	17	3,550	19,800	765	4,750	1.34	18.16	3,440,000
Wenatchee—Cashmere	7	1,250	21,400	650	3,770	3.01	40.92	2,730,000
Snoqualmie—Snoqualmie	3	344	13,900	570	2,660	7.72	104.98	1,860,000
Chelan—Mouth	10	950	9,810	245	2,330	2.45	33.36	1,690,000
Baker—Mouth	4	270	17,400	634	2,300	8.16	111.00	1,670,000
Methow—Pateros	10	1,710	14,800	264	1,790	1.04	14.16	1,300,000
White—Buckley	5	424	14,600	390	1,580	3.73	50.64	1,150,000
Cedar—Ravensdale	12	149	13,600	110	681	4.57	62.05	493,000
Puyallup—Electron	5	91	3,200	120	477	5.24	71.25	346,000

The foregoing summary (p. 326) of discharge records of some of the larger streams of the state was compiled in the Tacoma office of the United States Geological Survey, from stream-measurements made during a series of years. The run-off of the various streams, as indicated in the column headed "depth in inches on drainage area," shows a wide diversity. The minimum is the case of the Snake, which comes from a region of low rain-fall and high evaporation, and the maximum is found in Baker River, which drains a large part of the great snow-fields and glaciers of Mount Baker, a locality of excessive precipitation and little evaporation.

Quality of Water

In the wells, springs, fresh-water lakes, and streams of the state the water has a high degree of purity. In chemical analyses that have been made of water from the rivers the low mineral content is conspicuous. In a series of analyses made by Van Winkle* he found that "the muddiest and the most strongly concentrated water, that of Snake River near its mouth, after the stream has traversed an arid plain, contains only 131 parts per million of dissolved and 52 parts of suspended matter." Van Winkle also found that the drainage of the Cascades and Olympics, as shown by analyses of water from various rivers, "carries less than 90 parts per million of dissolved solids and several mountain streams frequently carry as little as 50 parts." Except for the glacial streams the waters of the rivers are very clear, with a minimum of matter in suspension, and the proportion of dissolved matter is far below the average.

In some of the more sluggish streams of western Washington, where the vegetation is luxuriant, a perceptible amount of organic matter may be noted in the water, especially when the water has been retained in swamps or shallow lakes for some time. In eastern Washington, where there are a few lakes without surface outlets, the waters have become charged with certain soluble salts. The best known lake of this character, Soap Lake, near Ephrata, contains in solids 28 parts per thousand, mainly sodium carbonate, with smaller amounts of sodium sulphate and sodium chloride.

Utilization

Water for Domestic Use.—It goes without saying that the highest use of water is that for domestic purposes. In the humid portions of the state excellent water in abundance is readily obtained for house use, from wells, springs, or streams. It is only in the most arid localities that any trouble is experienced in securing an ample water supply. Even here good water may be had from occasional springs or from deep wells. Since wells having a depth of several hundred feet, sunk in hard rock, are expensive, it occasionally happens that the homesteader or "dry farmer" will secure the necessary water for his house and barn by hauling it some distance in a large tank.

*Van Winkle, Walton. *Quality of the Surface Waters of Washington.* United States Geological Survey. Water-Supply Paper 339, p. 93–1914.

The cities and larger towns of the state are all fortunate in obtaining large supplies of pure water with the minimum of expense. It is the rule for the municipalities to own their own waterworks. Those that are located conveniently for that purpose obtain their supplies from the mountain streams, and provide an intake for the water mains that is beyond any likelihood of contamination. Natural lakes are sometimes used for storage, and when these are not at hand artificial reservoirs are provided. Nearly all the towns of the state secure their water supplies from streams and lakes, except in the regions of low rain-fall where most of the water courses are intermittent in character. In such instances deep wells are driven into the bed-rock, usually basalt, and the water then pumped into storage basins from which it may be distributed by gravity.

Irrigation.—The second use for the water supply of the state, in order of importance, is for the purpose of irrigation. In the interior basin, along the Columbia, Snake, Yakima, Wenatchee, Methow, Okanogan, and other streams, below the 1500-foot contour, the natural rainfall is rarely sufficient to grow a crop. This means that irrigation must be practiced over several thousand square miles of arid country if agriculture in any form can be successful. As a rule the soils of the desert are deep and of good quality. With water readily obtained, under gravity, it is not surprising that irrigation is now of prime importance in our economic development. Under cultivation at the present time, and in projects under way or definitely contemplated, almost a million acres of arid land are involved. Since the levels of water in the Columbia and Snake are so low with respect to the adjacent country these streams are drawn upon for irrigation only in a very limited way, and then by pumping. The streams from the mountains bring the water that is most used for irrigation, because only gravity methods of distribution need then be employed.

More than half of the 500,000 acres of irrigated land of the state is located in the Yakima Valley, the water coming from that stream and its tributaries. Storage facilities in the way of both natural and artificial reservoirs may readily be provided so that the entire run-off of the river system can be used for irrigation. By referring to the foregoing table of discharge records it will be seen that the yearly average run-off of the Yakima River amounts to 3,440,000 acre-feet. If we assume the duty of water to be from three to three and one-half feet per acre it will be seen that if all the water of the Yakima could be stored and utilized it would irrigate one million acres of land. It may be stated conservatively that a perpetual water right in that locality is worth not less than seventy-five dollars per acre. It is not difficult to see from these figures that the value of the water of this one river for irrigation alone is not far from seventy-five millions of dollars.

While the average rainfall in all parts of western Washington is ample for all kinds of agriculture, the drouth that usually prevails in July and August causes some severe limitation in the length of the growing season. It is recognized that even in the humid belt irrigation would be very desirable when the

rains fail in the summer and when evaporation removes the last moisture from the soil. At several places, on a small scale, irrigation has been begun in western Washington, and without doubt it will lead to a very general practice.

Water Power.—The third great utility of water is for power. It is evident that in a state where the precipitation is so heavy over large areas, and where in short distances the streams make rapid descents from high mountains to the sea, water power should be very abundant. In a report of the Commissioner of Corporations on Water-Power Development in the United States, under date of March 14, 1912, the minimum potential power of the whole country, calculated at 75 per cent efficiency, without storage, amounts to 26,736,000 H.P. In the same series of calculations the estimated horse-power of the Pacific Coast states is as follows: Washington, 4,932,000; Oregon, 3,148,000; and California, 3,424,000. It is thus shown that on the Pacific border nearly one-half the water-power of the United States is to be found and of this amount more than one-third is in Washington. It is apparent that in a state like this, where storage facilities may usually be provided at a cost that is not excessive, the possible amount of power may be greatly increased over the above estimates. A contributing agent of great value to the water-power possibilities of the state is the fact that so many of the rivers head in great snow-fields and glaciers, whereby the flow of the streams in the months without rainfall may be kept constantly at a high mark by the rapid melting of the ice and snow.

A careful study and estimate of the available water-power of the state is being made by the United States Geological Survey and the State Geological Survey, under a scheme of cooperation. The field-work for the Cascades has been almost completed and three of the seven reports have been printed. They are known as "Water Powers of the Cascade Range," Parts I, II, and III and have been issued as Water Supply Papers 253, 313, and 369. In these reports which cover the southern half of the Cascades, but including less than half the water-power of that range, the horse-power for the chief streams may be tabulated as follows:

	Horse-power	
Stream	*Minimum flow*	*With storage*
Klickitat	154,000	154,000
White Salmon	105,000	105,000
Little White Salmon	5,500	5,500
Lewis	78,000	78,000
Toutle	44,000	44,000
Cowlitz	105,000	175,000
Nisqually	27,700	35,700
Puyallup	36,800	40,400
White	57,400	102,000
Cedar	5,400	37,900
Yakima	74,700	132,000
Total	693,500	909,500

In the surveys of the first five streams in the above table the amount of storage was not determined and hence the estimates in that column are the same as under minimum flow. It should also be pointed out that in the case of the Yakima there will be available during the irrigation season a total of 287,000 horsepower.

In the entire state hydro-electric plants with a total capacity of about 400,000 horsepower have been developed. It is evident that Washington has more water-power than will be utilized for many generations. New units are placed in commission as the population increases and there is a sale for the power. Today the water-powers of the state supply practically all the electric energy used in municipal lighting, street and suburban railways, and in driving a large portion of the machinery used in the varied manufacturing enterprises.

Logging and Navigation.—The use of streams for logging is important in the sections of the state. This affords not only a means for cheap transportation but storage facilities are frequently provided in the streams near their mouths where the logs may be kept in good condition until they are cut in the mills. Navigation is of minor consequence despite the fact that the rivers are numerous and carry large volumes of water. This is mainly true because of the general velocity of the currents and the frequent occurrence of rapids, cascades and water-falls. By the use of locks at two points the Columbia, although relatively rapid, has been made navigable from its mouth to the foot of Priest Rapids, a distance of about 400 miles. The stretch of river from Wenatchee to the mouth of the Okanogan has been navigated for a number of years; and small freight boats make frequent trips on the upper river from the mouth of the Okanogan to Kettle Falls. By the removal of certain obstructions near its mouth Snake River has been opened for passage throughout its course in Washington, but only boats of small size run above Clarkston. The Okanogan for some years, during the high water of early summer, has been navigated as far as Riverside. The Cowlitz has navigable water as far as Toledo; the Chehalis as far as Montesano; while small steamers have made occasional trips on the Skagit as far as Hamilton.

Relation to Industrial Life

The water resources of the state now have, and always will have, intimate relations with the industrial life of the people. If we take the most fundamental of all occupations, that of agriculture, we find that precipitation is of primary importance in determining the kind and value of farm products. Already about the state we have come to recognize centers of cereal production—here wheat, there barley, somewhere else oats or perhaps corn. In fruit growing there are some areas best adapted for apples, others for grapes, and still others for peaches and apricots. The districts best adapted for forage crops are well known, and alfalfa, timothy, and clover have their recognized localities of peculiar advantage. In all these instances the governing factor has not been alone the total annual precipitation, but the kind of precipita-

tion, the relative amounts of rain and snow, the seasonal variation, and the accompanying conditions of cloud and sunshine.

In the forest the practical lumberman knows where to look for the best Douglas fir, or cedar, or hemlock, or spruce, or pine, or for whatsoever variety of tree that he desires. Among the men of the woods such expressions as "cedar swamps," "alder bottoms," "hemlock ridges, "fir uplands," "pine slopes," and many others are very common. In the distribution of the forest species the annual rain-fall is of paramount importance. But of almost equal significance is the depth of the soil and its varying ability to retain moisture, coupled with the amount of evaporation which depends so much upon the percentage of cloudiness and sunshine.

The business of manufacturing, more particularly in the future, will come to be inseparably connected with the water resources of the state. This will come mainly in the widespread utilization of the power to be had from the mountain streams. The highlands of Washington abound in opportunities for the development of comparatively small hydro-electric plants capable of driving all the machinery in their immediate localities. The larger installations will make possible the electrification of the railways, supply the necessary current for the light used in the cities and towns, and provide all the power that is needed in the industrial centers.

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THE FORESTS OF WASHINGTON

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OF a total land area of nearly 45,000,000 acres in the State of Washington, approximately 25,000,000 acres are covered with forests of merchantable timber. What the original stand was may never be known with any degree of accuracy. It is estimated that between 350,000,000,000 and 400,000,000,000 feet board measure remain. This represents almost one-eighth of the present stand in the entire United States, and has a value of almost 400,000,000 dollars in stumpage alone. Eighty-eight per cent of the standing timber occurs west of the Cascades, about eight per cent between the Cascades and the Columbia-Okanogan River valley, and four per cent east of this valley. About one-third of the timber is included in the National Forests of which there are eleven in the state, comprising a total area of about 10,000,000 acres, and nearly two-thirds is held by private timberland owners.

The crest of the Cascades makes a natural division line on either side of which the conditions of forest growth are quite different. The entire portion west of this line, including also Oregon and northern California, was originally covered with one solid forest. The mild climate, heavy rainfall, and generally humid atmospheric conditions have resulted in the production of a forest than which there is none more wonderful in the density of its growth and majesty of development in the entire world. In Washington and Oregon Douglas fir is the chief species. Trees 8 to 10 feet in diameter, towering 250 feet in height are not uncommon and it is not at all rare to find more than 150,000 feet of merchantable timber to the acre. The ground is densely covered with underbrush. East of the Cascades the climate is drier and marked by considerable extremes of temperature. This portion of the state consists largely of open prairie-like agricultural and grazing lands. Except for small isolated areas scattered here and there the forests are confined mainly to three regions, (1) the east slope of the Cascades including the foot-hills, (2) a belt 30 to 50 miles wide along the entire northern boundary of the state, and (3) an area, probably about 24 miles square, in the south eastern corner of the state. The principal species is western yellow pine. The trees are smaller

Note—What is said in this article concerning the forests and forest conditions of Washington will hold true so far as general principles are concerned for those of British Columbia and Oregon. The general forest conditions in Oregon and Washington are practically identical. The chief differences between the two states will be found in the amount of standing timber and the annual cut. Oregon has not as yet cut into her forests as heavily as Washington. According to the last census with a cut of nearly 2 billion feet she ranked 9th in point of production in the United States, whereas Washington ranked first. According to a report of Mr. H. R. MacMillan, Chief Forester of British Columbia, the entire forest production of the Northwest including British Columbia, Washington Oregon and Idaho has an annual value of 200,000,000 dollars. He also states that 33 per cent of the public wealth of British Columbia, 42 per cent in Washington, 45 per cent in Oregon and 31 per cent in Idaho, is derived directly from the logging camps, sawmills and other forest occupations.

and slower growing and the forest itself more open and generally park-like in character than west of the mountains. Underbrush is usually absent but grass is abundant. The stand per acre will probably not average much over 12,000 feet.

The forests have furnished the chief raw materials upon which the early development of the state was built. Many of the cities and towns of the northwest coast owe their rapid development and their present importance more directly to the forests than to any one other natural condition. The industries of Portland, Seattle, Tacoma, Everett, Bellingham and the entire Grays Harbor and Coos Bay regions, to within comparatively recent times were more directly dependent upon the products of the forest than upon the products of fields, farms, fisheries and mines combined.

The following tables show the relative importance of these industries:

TABLE I

*Value of Lumber and Timber Products Compared to Agriculture.** (1910).

Lumber and timber products		$ 89,155,000
Wood-lot products		3,754,293
Total forest products		$ 92,909,293
Grain	$78,927,055	
Domestic animals	10,249,346	
Dairy products	8,746,041	
Eggs	4,311,000	
Orchard fruits	4,274,000	
Garden truck	3,000,000	
Small fruits	941,415	
Total all agricultural products		$110,448,855

TABLE II

Forest Products Compared to Other Manufactured Products

All manufacturing industries—value	$220,746,000
Lumber and timber products	89,155,000
Value of forest products in percentage of total	40.4%
Annual wealth added to the state through lumber manufacture in percentage of total added wealth due to manufacture	50.8%

The above tables show without further comment the tremendous value of our lumber industry to the state. The importance of this is emphasized even more when it is known that about 80% of this total annual value of the lumber and timber products goes into general circulation among the people of the state for wages and supplies and that 63.3% of all the wage earners engaged in manufacturing in the state are employed in the lumber industry.

*All figures according to last census.

The Pacific Northwest in normal times furnishes a larger proportion of the lumber cut of the United States than any region of similar size.** Washington is the largest lumber producing state in the Union, and has held that position since it first took the lead in 1905.

Like all of the states traversed by mountain chains, Washington will always have a large proportion of land that will not be economically adapted to any purpose better than to the production of timber crops. It has been estimated that in the western part of the state perhaps 50% of the land will be permanent forest land.

This condition leads to an economic situation in the state that demands attention. It rests upon two conditions. The first is the present large economic value of the lumber industry, the other is the large area of land within the state that will be almost worthless unless it is made to produce timber crops. Without a sufficient lumber industry the wood crops that can be grown on the non-agricultural and the non-grazing lands will have no value and without the raw materials produced by continuous wood crops we can have no lumber industry of importance in the future. This does not mean that a curtailment in the production of lumber to husband our supply would be an advantageous thing. On the contrary much of the land covered with virgin forests is producing practically nothing now because the trees are over-mature and hence decay probably fully balances the new growth. If this old timber were gradually cut off and new growth established the land would again become increasingly productive. The problem can only be met by a proper encouragement of the use of wood and by provisions for reforestation under the direction of the state. This means state forests and a state department of forestry organized to carry on a system of forest management on the cut-over forest lands and a research department for the study of the utilization of forest products. Although Washington, like her sister states of the Northwest, has the conditions which should always make her one of the most important timber states of the Union she is doing far less than most other states to insure her future along these lines. Unless definite action on this question is taken soon, history will here repeat itself and we shall be confronted with the same economic conditions that arose in many of the timbered regions of the East where the problem had finally to be taken up with the expenditure of large sums of the public funds, and even then was only partially solved.

In the past the chief need in the care of the forests has been fire protection. During the dry season which occurs in July, August, and September, Washington has for many years past suffered severe losses through the burn-

**It is only fair to state that since the above figures were compiled the lumber industry has been passing through a decided period of depression and that the value of agricultural products of all kinds, but more especially of wheat, produced annually, as also the manufacturing industries other than lumber, have increased with marked rapidity. Yet all present indications are for an immediate increase in lumber production very considerably in excess of any quantities produced since last census.

ing of timber and the entire population has had to contend with the very disagreeable feature of having the sky clouded and the atmosphere tainted with smoke at the season which should be the most beautiful. A widespread campaign of education and organized effort and cooperation on the part of the National Forest Service, the State Forester and the Washington Forest Fire Association (comprising the timberland owners of the state) has led to a system which practically insures against the loss of timber from fires. The smoke nuisance caused by the necessity of burning slashings will however probably be with us for some years to come. Each of these institutions receives its support from a different source but the work of protection is so organized that all parties work together for the common end of protecting all the timber of the state. Although owners of something less than one-third of the acreage in private hands do not contribute to this system they nevertheless gain practically the full benefit, for in a system such as this must be in order to be effective, an unprotected area becomes a menace. During 1915 the timberland owners assessed themselves 2 cents per contributing acre and had a net operating cost of 1.78 cents per acre.

Douglas fir, also known as red fir, yellow fir and Oregon pine, is the chief species of the north-Pacific slope. Excepting the Sequoias (Big Trees) it is the most gigantic tree of the region. Under normally good conditions of growth it reaches a height of from 180 to 190 feet and a diameter of 3½ to 6 feet. Such trees are usually between 300 and 400 years old. Under exceptional conditions trees over 250 feet in height and 8 to 10 feet in diameter are found and these trees often approach 500 years in age. This species alone composes about 25 per cent of the timber supply of the country and by far the greater part of it is located in Washington and Oregon. From the standpoint of its adaptability to forest management it is one of the best species known. It is easily reproduced and grows very rapidly. Studies made in second-growth stands show that in a period of 100 years on the best soil conditions it will yield nearly 80,000 feet to the acre without any special care other than fire protection. It has an annual growth of between 800 and 1,500 feet B. M. per acre per year.

From the standpoint of general usefulness it has practically no rival. Though there are other species that are better adapted to certain specified purposes, Douglas fir is being used for nearly all purposes where wood can be used. Owing to the large size of the trees they contain a large amount of clear lumber. The wood varies greatly in texture and color from a fairly soft, fine-grained, straw yellow to a hard, coarse-grained, red brown. This difference in condition has led to two distinct names among lumbermen, the term yellow fir being used for the former and red fir for the latter. Botanically they are, however, the same species. For use as large structural timbers, Douglas fir has no equal in that it is stronger than any other coniferous species and at the same time lighter than its nearest competitor, the long-leaf pine of the Gulf States.

The other important timber species of the state, in the order of their importance from the standpoint of annual cut are Sitka spruce, black cottonwood, western hemlock, western yellow pine, western red cedar, red alder, western white pine, Oregon maple, western birch and Oregon oak. All of these occur at the lower altitudes and with the exception of the western yellow and the white pines, they are found for the most part only west of the Cascades. The coniferous species also grow together in mixed stands or may be found in pure stands of varying extent consisting of only one species. The hardwood or broad-leaved species occur chiefly in small scattering stands in the river valleys. The western yellow pine is the principal tree east of the Cascades where it occurs largely in pure or nearly pure stands, and the white pine is found on both sides of the mountains.

Western red cedar is the source for the famous red cedar shingles, and western Washington produces from this species, 66.6% of all the shingles manufactured in the country. Western hemlock, although perhaps next in abundance to Douglas fir has not found general favor in the lumber market chiefly because of the bad reputation of the eastern species of the same name. The western species, however, has proven itself to be nearly as good as the Douglas fir for many uses and in time the public mind will be convinced that it has practically none of the bad qualities of the eastern hemlock. Spruce is used largely for wooden containers, and spruce and cottonwood are the chief sources of raw material for the production of wood pulp. Although our supply of broad-leaved or hardwood varieties is comparatively small, the state is able to meet its present demands for such wood.

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FISHERIES AND FISHERY PRODUCTS OF WASHINGTON

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THE State of Washington is fortunate in possessing an extended shore line and a large area of both salt and fresh inland waters. The climate is so mild and equable, and the other conditions are so varied and favorable, that the waters of the state furnish a most suitable environment for an abundant and diverse fauna and flora. The protected waters of the Puget Sound, Grays Harbor and Willapa Bay furnish excellent shelter for the large fleet of boats engaged in harvesting the products of the deep. Under such favorable conditions, it is not surprising that the commercial products obtained from the waters of Washington are worth, annually, many millions of dollars.

The Salmon

The salmon are by far the most abundant and valuable of the fish found in the waters of the state. In fact, the salmon fisheries of the Pacific Coast of North America far exceed those of any other waters of the world. Washington lies right in the midst of this industry and probably reaps more from it in a commercial way than any other state or territory bordering on the Pacific Ocean.

There are five closely related species classified together under the generic name, *Oncorhynchus*. The largest and best known of the five species is the *king or chinook salmon*. It ranges along the coast from southern California to the Arctic Ocean, and down the Asiatic coast to China, but is taken in largest numbers in the Columbia River. This fish has an average weight of 22 to 23 pounds, with a maximum weight that is very much greater; individuals have been taken ranging from 70 to 100 pounds. Large numbers of these fish are used fresh by local consumers and large shipments are made in cold storage to eastern markets.

The sockeye or blueback salmon is much smaller than the king salmon, having an average weight of not more than 5 pounds and reaching a maximum of about 12. This fish has, in recent years, passed in commercial importance the king salmon and now furnishes the greater part of the canned salmon of the world. Because of the deep enduring color and firm texture of its flesh it is considered more desirable as a canned product than the other salmon which do not possess both of these qualities. The most important sockeye river is the Fraser of British Columbia. During the spawning season they enter this river in incredible numbers. On their journey from their feeding banks in the ocean to the spawning grounds in the Fraser River, they pass through the northern waters of Puget Sound lying within the borders of the State of Washington, thus affording an opportunity to American fishermen to take them in large numbers. This fish is taken in still greater num-

bers in the waters of northern British Columbia and southeastern Alaska. In the latter territory it goes by the name of red salmon.

The silver or coho salmon has an average weight of about 6 pounds and reaches a maximum of 30. This species is abundant in the waters of Washington. Because of its pale color, it is not much in demand as a canned product, although it has a flavor little if at all inferior to that of the sockeye.

The humpback or pink salmon is the smallest of the five species, having an average weight of about 4 pounds and a maximum of about 11. It runs in large numbers in the Puget Sound every second year and in lesser numbers on alternate years. It appears in southeastern Alaska in much larger numbers than anywhere else. Its flesh is pink and not so firm as that of the sockeye salmon; nevertheless it is an excellent food fish and but little inferior to the sockeye.

The chum or dog salmon averages about 8 pounds in weight. It is not so highly prized for canning because of its pale color and mushy texture, but is valuable for salting and smoking. It enters many of the coastal streams of Washington to spawn.

The steelhead trout is not a salmon, but, because it is considered as such by many people, it is here treated in connection with the salmon. The steelhead is a very important fish commercially and much sought after as an article of fresh food. It is a large fish averaging about 12 pounds and reaching a maximum of 45 pounds.

Habits of the Salmon

The salmon make their home in the salt water, coming into fresh water only at the spawning season. The length of life varies in the different species. Stated in general terms, the king salmon lives four years, although many live five or six or even more years, the sockeye and the dog salmon live four years, the silver salmon three or four, and the humpback two years. At maturity they seek the fresh water in vast numbers for the purpose of spawning. From the time they start for the fresh water until the time of their death which follows shortly after spawning, they take no food, although it may require many weeks to reach the spawning grounds. They seek, as a suitable place for depositing their eggs, the gravelly bottoms of the shallow upper streams. After spawning they swim or float about aimlessly in an exhausted condition until they die.

The steelhead, like the salmon, seeks the fresh water in which to spawn, but unlike the salmon it returns to the salt water where it completely recovers from the effects of the arduous journey to the spawning grounds and later seeks the fresh water to spawn again.

Fishing Methods

A variety of methods are used in catching salmon. The oldest and one of the most popular equipments with the fishermen of the coast is the gill

net. This net is constructed with meshes of such a size that the fish can easily get their heads through but not their bodies. When they find it impossible to pass through the net they try to back out of it and in so doing the twine slips inside the gill covers and they are caught. These nets are used in and at the mouths of rivers and in channels where the fish run in large numbers. They are either anchored in place and left for a time or they are floated down the stream attended and directed by the fishermen in charge.

On the Columbia River the beach seine is used very extensively. The net, which is several hundred feet in length, is piled in the stern of a boat. One end of the net is made fast to the shore and as the boat sweeps out into the river the net is paid out. The boat makes as wide a semicircle as the length of the net will permit and after the net is all out horses are used to haul it to shore as quickly as possible. In this way many fish are caught.

The most efficient method of taking fish in the more open waters is by the use of the purse-seine nets. These nets are 1500 to 1800 feet long and 80 to 100 feet wide and are operated from the sterns of power boats. These boats are 40 to 60 feet in length and propelled by gas engines of 25 to 60 horse power. On arriving at the fishing grounds an eager look-out is kept until the school of fish is sighted; then a large row-boat which is towed astern is released and the seine which is made fast to this boat is paid out from the large boat while it makes a circle of as great a diameter as the length of the net will permit. When the circle is completed, both ends of the pursing rope, which passes loosely through rings in the bottom of the net, are hauled in by a winch worked by the engine until the bottom of the net is completely closed. Then the net is hauled aboard until but a small part of it, in which are enclosed the fish, is left in the water. The fish are then brailed out into the hold of the boat and the operation is ready to be carried out again. There is a fleet of about 400 of these boats on Puget Sound, each of which is manned by 7 or 8 men and valued, with its equipment, at $4,000 to $7,000.

Another very efficient method of taking fish is by means of traps set in the shallower waters near shores where the fish run in large numbers. The trap consists of a lead not more than 2500 feet in length consisting of wire netting fastened to piles driven firmly in the ground. The netting reaches from the surface of the water at high tide to the bottom. At one end of this lead is a peculiarly formed trap consisting of several parts the last of which is a large square bag made of heavy netting known as a spiller. The fish follow the lead which directs them into the trap and finally they find their way into the spiller from which they cannot escape. The fishermen lift the spiller and remove the fish, as a rule, daily. Record catches of 40,000 to 50,000 fish have been taken at a single lift of the spiller.

Another interesting device for taking fish, used principally on the Columbia River, is the fish wheel. These wheels average about 24 feet in diameter, and ten feet in width. At the circumference of each wheel are fixed large scoops made of wire netting and shaped like dip nets. These wheels are

placed near the shore in water through which the fish pass in large numbers up stream. The current of the river turns the wheels and the fish that are taken in the scoops are carried up and dumped into chutes along which they slide into large boxes on shore.

Trolling is another common method of taking the salmon. Small power boats are used for this purpose. Usually three lines with spoons or baited hooks are drawn along behind the boat. This method combines sport with business but the sport is soon lost sight of in the business. Large numbers of king and silver salmon are taken by this method.

There are a number of other methods used in taking salmon but they are of minor importance when compared with those already described.

Salmon Fisheries and Canneries

Because of the great commercial value of the salmon, much capital is invested in appliances for taking the fish and in equipment for preserving and canning them.

The report of the State Fish Commissioner for 1913 shows that more than $12,000,000 was used to capitalize the industry in the state of Washington. Nearly 9,000 men were employed for the season. The total number of salmon caught by all methods in the state of Washington for that year was 41,439,441 which yielded a total of over $15,500,000. The total salmon products for the year from the entire Pacific Coast were valued at over $42,000,000. This is the greatest output in any one year in the history of the industry on the Pacific Coast. These large results are due to the big run of sockeye to the Fraser River, and the fact that the fishing interests were much better equipped for taking and canning the fish than ever before.

The season of active operation for the canneries of Puget Sound is very short. They usually start to can fish during the latter half of July and by the middle of September the canning for the season is practically over. On the Columbia River and other parts of the coast the season may be longer, but in every case the season and length of time the canneries are operated depends on the run of the fish to the spawning beds.

Fish Propagation

Owing to the increasing demand for salmon and consequently the large increase in the number taken it has been felt that unless some efficient means were taken to conserve this industry it would soon be ruined and the state would lose one of its most important resources.

Nature's method of keeping up the supply of fish is very wasteful. At the time of spawning a large per cent of the eggs are eaten by other fish living in the streams, many are buried so deeply under the deposits brought down by the streams that they are destroyed, and, again after the young are hatched, owing to their bright, attractive color and their helplessness, large numbers of them become victims to their ravenous enemies, so that but a small percentage of

the eggs spawned develop into fish that reach the ocean. Moreover the settlement of people along the water courses of the state help to render the natural propagation of the fish more precarious.

In order to preserve, if possible, this important source of food supply, both the United States and the state, through their fish commissions have undertaken by artificial means to propagate the salmon in large numbers. Together they have over 40 hatcheries scattered over the state in which more than 100,000,000 eggs are annually taken and cared for. After the young fish are able to take food they are placed in ponds and fed for a considerable time. When they are turned into the streams, it is believed they are able to take care of themselves much better than if they had been turned free at the time of complete yolk-absorption. By this means over 80 young fish are turned out for every 100 eggs taken and it is believed that a very large percentage of those released will find their way to the ocean.

Other Fisheries of the State

Halibut.—The fish next in commercial importance to the salmon is the halibut. Formerly this fish was found in abundance on the banks of the Washington and Vancouver Island coasts, but in recent years these areas have been practically exhausted, so that halibut fishermen have been driven to the banks lying between the north end of Vancouver Island and Alaska where the fish are found in abundance.

A fleet of 100 halibut vessels are owned and have their headquarters in Puget Sound. Out of a total catch of over 66,000,000 pounds for 1915, more than 33,000,000 pounds were handled in Seattle. Because this fish is prized so highly as a fresh food product the bulk of the catch is packed in ice and shipped to eastern markets where it is in great demand.

The cod-fish industry is as yet in its infancy and only a few men and vessels are engaged in it. Of the 25 vessels used in taking and carrying the fish 8 belong to Puget Sound. The fish are taken in Alaskan waters and handled through the various ports of the coast.

Herring are taken in large numbers in Puget Sound during the spring months but almost the entire catch is used as bait for the halibut fisheries.

Smelt and chad are taken in considerable numbers in the waters of the state. The smelt is native but the chad has been introduced into the Pacific waters from the Atlantic. The chad promises to become very abundant.

By-Products of the Fisheries

Formerly thousands of tons of offal were dumped each year from the canneries and fish concerns into Puget Sound, polluting the waters and destroying life. Now all this material, together with fish not considered good for food as dog fish, skates, and sharks, is used in the manufacturing of oils, glue, and fertilizer.

Shell-Fish

The oyster is by far the most important of the shell-fish found in the waters of the state. Extensive oyster beds are located in Willapa Bay, Grays Harbor and Puget Sound. According to the report of the State Fish Commissioner there are more than 14,000 acres of oyster lands in the state reserves, added to this are some thousands of acres in the hands of private individuals.

In the earlier years of the industry, the oystermen depended entirely on the natural resources of these beds. After a time they found that the beds were being so completely depleted that it was no longer profitable to work them. After a number of experiments that were but partially successful they evolved the method now in use, which has resulted in making the beds highly productive. By this method many areas of tide lands varying from one-half to sixteen acres in size were surrounded by substantial walls of reinforced concrete which were able to retain enough water to keep the beds covered while the tide was out. The enclosed areas were made practically level and then covered thickly with oyster shells or other debris of a similar character which served as attaching surfaces for the young oysters. After these beds are seeded down it takes three or four years for the young oysters to grow to a marketable size. Hundreds of acres are now under this form of cultivation and the results are highly satisfactory. Lands thus prepared are valued at upwards of $2,000 per acre. Partly due to the diminishing returns from the native oyster beds and partly to the desire to introduce into local waters a most important resource, the eastern oysters were some years ago introduced. The young of the eastern oyster's were shipped by the car load and distributed over the beds of the state where they developed into as fine a product as can be found in the east. The one drawback is the failure of the eastern oyster to reproduce in the colder waters of the West, thus necessitating the continued shipment of the young from the East. In recent years, the fact has come to light that the eastern oysters are reproducing in Willapa Bay and that the results are all that could be desired. Experiments will be made to determine whether or not the oysters now reproducing in Willapa Bay will reproduce in the other waters of the state.

Clams, crabs and shrimps form an important part of the shell-fish industry of the state. There are a number of canneries on the coast and on Puget Sound engaged in canning clams. The entire output of shell-fish for 1915 was valued at nearly $600,000.

Attempts are being made by the United States Fish Commission to introduce into the waters of Washington the lobster of the Atlantic coast. Large shipments of them have been planted in the Puget Sound waters, around San Juan Islands, but it is too early to predict what the outcome will be.

MINERAL RESOURCES OF WASHINGTON

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THE rocks occurring at the surface in the state of Washington are extremely varied. Those forming the Cascade Mountains and the Okanogan Highlands are in part the result of the cooling and consolidation of liquid rock deep beneath the earth's surface and in part the result of the baking or metamorphosing of sandstones, shales, and limestones. Such conditions have rendered it possible for the development of metaliferous mineral deposits such as gold, silver, copper, zinc, antimony, molybdenum, tungsten, chromium, etc.

The Columbia Basalt Plateau of eastern Washington is largely composed of nearly horizontal layers of basaltic lava flows with interbedded layers of sandstone and shale. Mantled over these formations are gravels and sands which were formed by glaciers and former rivers. In places these lavas attain a total maximum thickness of five thousand feet. They are the result of the cooling and consolidation of liquid rock which came up through numerous fissures and veins in the earth's crust from molten reservoirs existing below, and flowed out over it. Such conditions are as a rule not conducive to the development of metaliferous mineral deposits. Such basalts do however constitute a valuable source of material for road building purposes. They occur in the Puget Sound Basin and in the lava plateaus of Washington.

Coal

With the exception of the Olympic Mountains and the San Juan Islands the low hills of western Washington are composed of alternating layers of shales, sandstones, conglomerates, and lava flows. These were in part formed in lakes and in part in former embayments of the ocean which at times covered much of this area. During that epoch climatic conditions were much warmer than today and vast forests of tropical plants were growing on the land areas and in the swamps. From time to time the land areas were slowly being elevated and depressed with respect to the shore lines. As a result the tropical forests consisting of palms, figs, etc., were buried and covered with sands and muds. Ultimately the plant remains were converted into coal and the original interbedded horizontal layers of sandstone, shale, and coal were differentially subjected to pressure from below and folded, squeezed and in places rent asunder by faults. At the present time these rocks are largely covered with gravels and sands of glacial origin. The coal deposits which were formed in this manner vary greatly in general character and quantity. Some beds are of commercial importance and are being mined at the present time. Coal deposits of economic importance occur in Kittitas, King, Pierce, Whatcom, Thurston, and Lewis counties. The coal ranges in character from a bituminous to a lignite grade. The higher grade coals are being mined

at the present time in King, Pierce, and Kittitas counties and are marketed in both eastern and western Washington. Coal constitutes a considerable portion of the commercial mineral wealth of the state.

The following table includes the yearly production and valuation by counties of the coal mined during the period from 1910 to 1912:

Value of Coal Mined

	1910	1911	1912
	Tons	Tons	Tons
Kittitas	1,661,650	1,256,745	1,237,427
King	1,242,340	1,259,521	1,063,110
Pierce	786,096	783,196	788,293
Lewis	179,484	172,734	128,377
Other Counties	42,329	100,619	143,725
Total tons	3,911,999	3,572,815	3,360,932
Total value	$9,764,465	$8,174,170	$8,042,871
Average price per ton	$2.50	$2.29	$2.39

Gold, Silver, and Copper

Gold and silver ores occur in the Cascade Mountains and in the Okanogan Highlands. They are being mined in several districts in Stevens, Ferry, and Okanogan counties. While there are market variations in the quantities and values of these ores, yet the geological occurrence does not greatly differ. The prevailing country rock is a green colored schist together with crystalline limestone, slate, and granite. All of these rocks are cut by numerous dikes. The gold and silver deposits usually occur in quartz veins. These veins vary greatly in thickness as well as in the value of the gold and silver content. Some veins when assayed yield only ten or fifteen cents in gold and silver to the ton of quartz while others may locally contain several hundred dollars to the ton. Usually those veins which do not contain more than two or three dollars of gold to the ton cannot be mined on a commercial scale. The average values of the gold and silver ores which are mined in this region probably range from two to ten dollars to the ton. Often such ores contain varying amounts of copper, zinc, lead, antimony, or arsenic. When these minerals are present they may add to the total value of the ore. Under such conditions quartz veins containing less than two or three dollars to the ton of rock might be commercially mined.

When quartz veins contain only gold and silver the rock is usually treated at the mine in a stamp mill where it is crushed to a fine powder, mixed with water and allowed to pass over plates covered with mercury. Whatever gold may be present in the powdered rock collects on these plates. The rock flour is carried off as a slime, and later the gold is recovered from the mercury. In order to mine such veins on a commercial basis the value of the gold which can be recovered from the rock must be greater than the cost of min-

ing the ore and extracting the gold in the mill. If commercial quantities of copper, lead, zinc, etc., are present the ores are usually shipped by railroad or wagon to some nearby smelter where they are roasted and treated by various methods to recover the mineral content. In neither case is it usually possible to recover all of the gold or other metal within the quartz.

Gold mining camps occur in several portions of the middle and northern Cascades. Certain districts which were formerly active are now performing only yearly assessment work in order to hold the mineral claims. Among the more important of these are Orient in Stevens County; Blewett in Chelan County, and Monte Cristo in Snohomish County. The most active gold producing district during the last few years is that around Republic in Ferry County. Copper deposits of small extent occur at several localities in the Cascades as well as in the Okanogan Highlands. The value of copper ores depends largely upon the copper bearing minerals forming the ores. Some minerals contain as low as 20 per cent copper while other minerals contain 80 per cent. The proportion of copper minerals to quartz in the veins varies considerably. Usually if the per cent of copper in the vein rock is less than one per cent the ore cannot be commercially mined. If the ore happens to be very rich in copper and the ore body small the same holds true. The copper deposits of Washington are small as compared with the great producing districts of Montana, Lake Superior, and Arizona. When the price of copper is high many of the mines in Washington can be worked on a commercial basis. When the price is low the majority of the camps become inactive. In 1900 they were nearly all active. During the past twelve years the copper districts of Washington have been characterized by their inactivity. Because of the present high price of copper many abandoned mines are being reopened. The more important copper camps are situated in Stevens, King, and Snohomish counties. The following table includes the yearly and total production of gold, silver, copper, and lead by counties from 1905 to 1912:

Value of Gold, Silver, Copper and Lead

County	1903	1905	1910	1912	Total 1903-1912
Ferry	$368,861	$107,160	$814,913	$ 712,250	$3,172,634
Stevens	75,412	212,523	106,319	339,347	1,352,640
Snohomish	139,305	72,747	105	721	362,027
Whatcom	48,418	91,338	26	2,201	338,972
Okanogan	71,917	8,779	14,894	18,220	184,129
Chelan	80,080	13,010	6,941	30,636	182,055
King	1,604	19,494	21,887	9,419	104,970
Total	$785,597	$525,051	$965,085	$1,117,794	$5,697,427

Limestones

Deposits of crystalline and dolomitic limestone occur in the central and northern Cascades, in the San Juan Islands and in the Okanogan Highlands. They are interbedded with quartzites and slates of Carboniferous or Mesozoic age. Some of the deposits are being used in the manufacture of lime and Portland cement. One of the largest lime producing plants is situated at tide water on the north end of San Juan Island at Roche Harbor. Cement plants are located at Concrete in Skagit County, at Bellingham in Whatcom County and at Metalline Falls in Pend Oreille County.

Clays

Clay deposits of varying grade are widely scattered through the state. They are the result of residual rock decay as well as deposits of marine, brackish water, and lacustrine sedimentation. Several plants are in operation in both eastern and western Washington. The clays are utilized in the manufacture of tile, brick, pottery, and terra cotta. The following table gives a list of the locations of the plants as well as the products of the clays of the state.*

Location of Clay-Working Plants

(2) or (3) signify number of plants.

City	County
Brick and Tile	
Chelan	Chelan
Taylor	King
Seattle	King
Chehalis	Lewis
Baker	Skagit
Sewer Pipe	
Kummer	King
Mica (2)	Spokane
Chester	Spokane
Freeman	Spokane
Stoneware	
Auburn	King
Clayton (2)	Stevens
Palouse (2)	Whitman
Paving Brick	
Renton	King
Taylor	King
Terra Cotta	
LaGrande	Pierce
Clayton (2)	Stevens

*From report on the Mineral Resources of Washington with Statistics for 1912 by Henry Landes, Washington Geological Survey, Bulletin No. 11, 1914.

Flint Fire Clay

Kummer (3) ..... King

Portland Cement Clay

Bellingham ..... Whatcom
Concrete ..... Skagit

Building Stone and Road Materials

Many of the sandstones and granites of Washington are used for building purposes. Sandstone quarries are operated near Bellingham at Tenino, and at Wilkinson in Pierce County. This stone has been used in the construction of many of the public buildings of the state. Similar use has been made of the granites at Index in Snohomish County and north of Spokane in eastern Washington. Road metal is obtained from the basalts of both eastern and western Washington. Quarries of this material have been operated from time to time along the Columbia River as well as in the Grays Harbor region and near Seattle.

In addition to the mineral products already described there are deposits of the rarer metals such as antimony, tungsten, molybdenum, and chromium whose extent and general character are at the present time very little known. The following table gives the value of the production of the different mineral deposits within the state during the years 1913 and 1914:

Non-metallic Products

	1913	1914
Coal	$ 9,243,137	$ 6,751,511
Clay Products	2,390,226	1,809,491
Portland Cement	2,350,898	1,140,121
Granite	773,194	1,068,042
Sandstone	560,468	450,436
Limestone	62,913	62,913
Marble	Not given	189,260
Lime	Not given	28,777
Mineral waters	18,886	
Sand and gravel	385,886	324,628
Totals	$15,964,501	$11,825,179

Metallic Products

Gold	$ 696,275	$ 557,173
Silver	200,068	146,468
Copper	147,883	103,571
Lead	8,909	2,555
Totals	$ 1,653,135	$ 809,767
Grand Totals	$17,617,636	$12,634,946

THE GROWTH OF THE CITIES OF WASHINGTON

By W. M. Gregory*

Normal School, Cleveland, Ohio

"WHY, I would not give a pinch of snuff for the whole country! Do you think your honest farmers of Pennsylvania, New York, Ohio, Illinois or Missouri will leave their farms and go on such an enterprise as this?" This is the statement of United States Senator McDuffie in 1843 when the Oregon Bill was passed in the Senate by a narrow margin. After its passage Daniel Webster, then Secretary of State, deemed the Puget Sound region of such slight value that it was nearly lost in the Oregon Treaty Negotiations of 1846.

The falsity of these short sighted visions has been fully shown by the subsequent amazing economic developments of the Northwest, making its present per capita wealth twice that of Ohio, Michigan, or Wisconsin. It is true that the first settlement in 1825 at Fort Vancouver on the Columbia River was a remote trading post of the Hudson Bay Fur Trading Company. It was fur that Captain Gray sought when he established a lonely station on Grays Harbor. The beaver skin was then valuable for hats but a change in London's fashions brought in the silk hat and with the natural decrease in demand for the beaver skin, the interest of the Hudson Bay Fur Company in this region gradually waned. It was a natural step from the fur to the fish of Puget Sound, and Doctor Manyard in 1852, one of the earliest settlers of Seattle, sought land along with the Denny family for a salmon packing plant. Along with these workers came one Yesler who built a saw mill near the fish packing shanty, thus the community started early in the progressive development of its natural resources.

The north to south extent of the Cascade Mountains through the center of the state was the barrier that determined the settlement of its eastern portion first. This was accomplished by Marcus Whitman in 1836 who established an Indian Mission at Walla Walla where he tilled the soil and first taught the natives how to irrigate the crops. On the western slope of the mountains the first settlements were along the edge of Puget Sound as it offered fine opportunities for trading and fishing. The first settlers on the Sound gathered at Tumwater, near the present site of Olympia, in 1844, and they at once harnessed the small stream for a combined grist mill and sawmill.

The real peopling of Washington was started by the Oregon Migration in the spring of 1843. This party, of more than one thousand people from Ohio, Indiana, Michigan, and other honest farmers of the middle west, had Marcus Whitman as one of the leaders and followed the Oregon Trail through the South Pass into the new country. Horace Greeley considered

*Mr. Gregory was a member of Summer School faculty of the University of Washington in 1915.

these people wholly insane but he lived to visit this region of marvelous possibilities and advised young men to go west.

The long caravans crawling slowly over the plains and the mountains did not bring the people very rapidly for in 1853 the total population was slightly less than four thousand and the native Indians numbered nearly six times the scattered groups of whites. The early comers spread over the new lands, selecting those sites that were best adapted for fishing, sawmills and trading posts.

Rapid Development

Following this period of small struggling centers of industry came a rapid and a tremendous development when the great timber resources were suddenly made accessible by the railroads that were extended into this region with marvelous rapidity. One of the earliest railroads was at Walla Walla in 1876, its rails were wooden stringers covered with rawhide. Its traffic was frequently delayed by the starving coyotes eating the hide track which is a minor incident in the rapid railroad development that enabled the state to jump from the difficult trail and the slow caravan to the more expeditious steam road. In 1880 Washington had less than three hundred miles of railroad and in the decade that followed its mileage increased ten times and the same period had an increase of 375 per cent in population. These decades of wonderful growth in population were due to the sudden opening of the vast forests to lumbering. The railroad found a ready market in the east or at a shipping port on the coast for the lumber, the salmon, and the wheat. The western terminus of each road became a port for the outlet of the regions of production. Thus the gathering points for manufacture or for shipping were the places that had the greatest growth in the early development of the state's natural resources. At present more than one half of the people are living in manufacturing or shipping communities of three thousand or more inhabitants. Washington has leaped from an undeveloped region of scattered sawmills and fishing ports to an urban state in which its percentage of urban people ranks eleventh among the states. The wagon road stage of development that stands in the growth of a community between the trail and the steam road was rapidly hurdled. Hence the rural life has developed slowly and at present only one quarter of the state is in farm land, for the exploitation of the forests has offered a more rapid source of wealth than the slower process of soil cultivation.

Importance of Puget Sound

In the vigorous growth of the cities of the western part of the state the forests and the railroads have been controlling influences to which must be added the geographical advantage of their location on the salt water estuary of Puget Sound. This Inland Sea of the Northwest reaches nearly one hundred miles eastward with its narrow arms of deep navigable water that extend into the lands for more than a hundred miles to the north and south. This "Har-

bour Country" offers to commerce more than 1,900 miles of shore line, many deep and easily accessible harbors surrounded by a land of equable climate. Further, this body of water is nearer Chicago, Alaska and Japan than is the rival harbor of San Francisco, and this is a great geographic advantage for Puget Sound in the competition for Pacific commerce.

It is about Puget Sound that the most vigorous growth of cities has taken place. The counties contiguous to Puget Sound are about one fifth of the area of the state and yet they have more than one half of its total population. The railroads reaching westward to this Inland Sea have made cities where they touch the open and navigable water of the Sound. The growth and development of these railroad and port towns has been due at first to the lumber, then to the fish, and later to the rich resources of Alaska and the extensive markets of the Far East. The materials and outfits for the Alaskan development have been shipped largely from the Puget Sound ports and in return they have controlled the Alaskan products. In the Far East markets the Puget Sound ports show their advantage in distance by their greater imports of raw silk and far greater shipments of iron products than San Francisco.

Seattle

Seattle is the first city of the Northwest because it has the most advantageous site on Puget Sound for the union of sea commerce and land trade. Seattle owes its growth more to its commercial interests than to the development of its nearby resources of coal, water power, and timber. John Holgate was the sole inhabitant in 1850; the Denny party came in 1851 and when a few months later Yesler started a saw mill, Seattle gave promise of being a typical "sawdust and salmon" town. Twenty years later it had about one thousand people who had increased the number of saw mills and fishing shacks that were scattered among the piles of logs and lumber.

The builders of the railroads to the westward discovered (about 1884) that Seattle's site, midway on the eastern edge of Puget Sound on a nearly straight channel to the ocean, was the strategic point for railroads to meet the deep sea navigation. Seattle is on a narrow peninsula between Lake Washington (fresh water) and the salt water of Puget Sound. The city has grown about Elliott Bay, along whose edge are the great navigation docks and the various railroad terminals. Entering Elliott Bay from the south is the Duwamish River, the tidal flats of which have been improved by dredging and filling, so that the two distributaries of the river are now known as the East and West Waterways and form commercial assets of great future value. North on this deep bay is Smith Cove where the largest steamship docks have been constructed. Extending through the northern portion of the city is still another addition to its commercial advantages—the long, narrow Salmon Bay, Lake Union and the Government ship canal that connects Union Bay, an arm of Lake Washington, with Lake Union and thus with the Sound. The area of the city that has been developed under these favorable conditions is some

fifty-eight square miles of land, while its lake and rivers are some eleven square miles and the salt-water about twenty-four square miles in addition. The land rises suddenly from the water's edge and in places like Magnolia Bluff the steep banks are very near the shore. The surface is one of rolling drumloidal hills with the longer axes generally north and south. The hills rise three to four hundred feet above the water and their summits are fine residential sites but they were such a disadvantage in the business section that they were removed in a true western fashion. The loose gravels and clays made it an easy task to use hydraulic streams to remove enormous quantities of the earth and in places a depth of more than eighty-five feet was removed to make the sixty miles of level streets required in the business section.

Seattle's growth was slow at first. Its trade was chiefly lumber and fish, but the coming of the railroad in 1884 was the initiation of a period of astonishing growth. In the twenty years from 1880 the city grew from three thousand to over eighty thousand. This was a time of the opening of one new field after another. First it was lumber and fish, then Alaska and the Far East trade. In 1896, with the discovery of gold in Alaska and the feverish rushes to the Klondike in 1897, followed by the opening of the Nome and Fairbanks region, Seattle's position gave it almost a monopoly in their trade. It was the logical outfitting center and likewise the port of entry for the gold, furs, and fish of the new lands.

The Far East trade for Seattle began about 1896 with the establishment of a steamship line to the Orient. Seattle holds first rank on the Pacific Coast in foreign imports of raw silk, tea, and fiber, while it exports canned fish, ironware, lumber, and coal. The foreign trade has grown from 15 million to 56 million dollars (1914). The domestic trade for 1914 was nearly 50 million dollars, one third of which was Alaskan. The building of railroads in Alaska will further stimulate this trade and the Panama Canal is furnishing a more direct and cheaper shipping route for products from Seattle.

Seattle's chief asset is its harbor; it is a typical port city and young as it is, ranks sixth among the ports of this country. Its advantageous position, at the "break in transportation" on the shortest trade line between our eastern states and the countries of the Orient and Alaska, has been the controlling factor in its development. The following table is an attempt to give definite value to the various influences that have been contributing factors in Seattle's growth:

	Per Cent
1. Commercial resources of its tributary lands (Alaska, Far East and the Puget Sound region)	20
2. Water transportation and ample dockage (Deep water harbor and municipal docks)	15
3. Geographical location and advantages of shorter routes (Strategic trade point on Puget Sound and on the shortest line between the Orient and the Eastern States)	15

4.	Railroad connections and seven competing lines	13
5.	Climatic conditions of fogs, winds and temperatures	10
6.	Character of citizens—"The Seattle Spirit"	8
7.	Topography and future area for expansion of trade and shipping	7
8.	Age of city and surrounding country	6
9.	Previous rate of growth	6
Total		100

Seattle is a young city that has about passed its period of most vigorous growth and its future increase will be slower. It is more than possible that the present time is one of those halts that frequently occur in cities that have had a very recent vigorous growth. In 1910 Seattle was the twenty-first city in population and in an estimate issued in July, 1915, it was ranked as the nineteenth city. This was based entirely upon the rate of increase previous to 1910 which the writer believes is much too high for the present times.

Spokane

Spokane, the second city of the state, began with a saw-mill and three men in 1872. The Indians regarded the falls of the Spokane River as the manifestations of the Evil Spirit, but the white men readily perceived their value for water power which is the present basis of the city's industrial strength. The growth was gradual until 1885, which was the year of the discovery of the rich Coeur d'Alene mines a few miles to the eastward. Since the opening of these mines, the city's growth has been vigorous, even the disasterous fire of 1890 was only a momentary check, and the city in 1915 had an estimated population of 142,990. Its rate of growth for the last decade is only slightly lower than that of Seattle. Spokane is a lumber center that draws its timber from the forests to the north and the east. It has many secondary industries that depend upon this lumber supply and cheap power. South and west of Spokane, the fertile and level lava plateau lands are the grain fields that supply the wheat for flour milling that ranks second in the industries of this "Minneapolis of the West." The industrial interests of which Spokane is a center are so different from those of the Puget Sound region that the state naturally divides into two political parties in direct response to these two physiographic regions that are respectively east and west of the Cascades. Spokane is the center of the Inland Empire and it is of interest to note in this connection that as late as 1907 it was seriously proposed to make this region a state, giving it the name of Lincoln.

Tacoma

Tacoma owes much to a group of railroad promoters who gave the city financial and transportation advantages as a stimulus to a growth that might have been greater had their sense of geographical location been keener. In 1873 this town of three hundred people was selected as the western terminus

of the Northern Pacific Railroad. The railroad promoters purchased some three thousand acres of land and controlled nearly thirteen thousand acres of the surrounding land. The city was planned at the head of Commencement Bay; vast sums were spent in building depot, warehouses, docks, and repair shops. The city has had its most rapid growth since it has been reached by competing railroad and steamship lines. The city is on a peninsula standing between Commencement Bay and the Narrows of Puget Sound. Where the Puyallup River enters Commencement Bay in the northeastern part of the city, the present extensive shipping interests had their origin. The present harbor has fourteen miles of water front and the city handles about forty per cent of the import and export trade of Puget Sound. The chief industrial interests are lumbering, flour milling and meat packing. The city had an estimated population in 1915 of 108,094.

INDUSTRIAL RESOURCES OF WASHINGTON

By H. K. Benson
Director of the Bureau of Industrial Research
University of Washington

ALTHOUGH the state of Washington has not developed a great manufacturing industry it nevertheless possesses an abundance of raw materials and certain other advantages which are unique and which give promise of extensive development in the future. Combined with a wealth of natural resources, the state contains a variety of exceedingly valuable secondary conditions, such as the equable climate of the coast, great harbors constituting a gateway for commerce with Alaska and the Orient, a topography yielding enormous water power, together with great scenic beauty. It is of interest to consider these various factors as fields for possible development.

Present Industrial Development

According to the figures of the last census the various industries of the state produce commodities valued at over 330 million dollars annually. Of this amount about one-third consists of agricultural products distributed as follows:

Grain	$ 78,927,053
Domestic Animals	10,249,346
Dairy Products	8,746,041
Eggs	4,311,000
Orchard Fruits	4,274,000
Garden Truck	3,000,000
Small Fruits	941,000
Total Agricultural Products	$110,448,855

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The total annual value of all manufactured products is reported at $220,746,000, representing a capital of $222,261,000 and employing 80,118 persons. Approximately 40 per cent of the manufactured products consist of lumber and other forest products, and this constitutes the largest industry of the state. Other manufactured products include flour mill and grist mill products, slaughter house products, canned or preserved fruits, meats, fish, etc.; foundry and machine shop products, butter, cheese, condensed milk, etc.; candy, crackers, pickles, baking powder, and other food products; brooms, cordage, trunks, woolen goods, jewelry, and other household commodities.

Industrial Resources

A survey of the state's resources shows that in many cases only a fractional utilization is made of the available raw materials and that manufacturing operations are capable of considerable expansion. A brief discussion of some of these possibilities will be given.

Forest Products

With nearly 400 billion board feet of standing timber and an annual cut of about 4 billion feet it would seem that the lumber industry will safely last for a century. In fact with a sane and constructive policy of reforestation of non-agricultural land there is reason to believe that the lumber industry will be permanent.

In the manufacturing of lumber, in logging and in land clearing operations a great waste of wood is now occurring. The quantity of wood cut is two or more times as great as the lumber actually produced. While some of this is used for fuel, much of it may be regarded as waste and is actually burned in order to get rid of it. In the manufacture of lumber each year the waste wood is said to approximate roughly 500,000 cords of logging waste left in the woods, 900,000 cords of sawmill slabs, and 1,000,000 tons of sawdust. Graphically it represents when cut into sizes of cordwood dimensions and then piled, a wall of wood 3000 miles in length, 4 feet in width, and 4 feet in height.

From the experiences of this and other countries where closer utilization is practiced, it is apparent that an opportunity exists for the establishment of secondary industries which will use this waste wood as raw material. The resinous woods yield by distillation, turpentine, tar, rosin and charcoal; the bark of the hemlock is rich in tannin; sawdust can be converted into alcohol; and wood pulp can be made from many species. Power in great quantities can be cheaply obtained from this waste by means of gas producers or steam turbines.

Fertilizers

The fertilizer resources of the state are almost of equal importance with its forest products. From the waters of Puget Sound about one-fourth of the fisheries products of the Pacific Coast are obtained. From the canneries may be obtained large quantities of fish offal which may serve as a raw material for nitrogeneous fertilizer and for fish oil. It is estimated that at least

$50,000 worth of waste might annually be sold to fertilizer plants which in turn will produce fertilizer materials and oil worth more than $200,000. Floating upon these same waters are the great beds of the giant kelp or sea weeds. These have been mapped by the United States Bureau of Soils, and, according to the survey, the kelp beds of Puget Sound produce annually 500,000 tons from which may be extracted 16,000 tons of potassium chloride. In connection with the kelp beds of the north Pacific on this western coast of America, more than twice as much potash may be extracted as is annually imported in normal times from Germany.

Recent investigations show that phosphate rock may be converted into soluble forms through the agency of the electric current. The large deposits of phosphate rocks in Idaho and the cheap water power of Washington with its abundance of coal and limestone offer favorable facilities for the manufacture of phosphate fertilizer material. In the manufacture of nitrates with our cheap water power and of other nitrogeneous fertilizers from fish waste; of potash from kelp; and of phosphates, the state of Washington will eventually develop a large industry.

Power

In the past, the industrial welfare of a community was dependent upon its nearness to a coal deposit, but in the Northwest coal has competitors in the great quantities of oil from California and the electrical power of its mountain streams. The total available coal supply of Washington is computed at 20,000,000,000 tons and nearly 4,000,000 tons are mined annually.

From the mountain streams of Oregon and Washington and within economical transmission to our larger cities on tide water may be generated at least one-fifth of the available water power of the United States, exclusive of Alaska. It is currently stated that electrical power can be generated at a cost not exceeding $7.50 per horsepower year, thus enabling electrical power to be used in the establishment of electro-chemical industries such as the production of oxygen, chlorine, bleaching powder, peroxide, nitrates, etc.

Agriculture

Agriculture is yet a dormant, undeveloped industry. Less than 10 per cent of the agricultural land of Washington has been improved and utilized for agriculture. More than 2,500,000 acres of logged-off land of agricultural character remain uncleared and idle. This is due chiefly to the high cost of clearing the land of stumps and debris left by the logger. In central and eastern Washington the problem has been different. Instead of the jungle the desert must be overcome. Irrigation has transformed large areas into orchards and meadows of great beauty and productiveness. But even there out of 2,000,000 acres of irrigable land not more than 25% has thus far been reclaimed.

The urgency of a more highly developed manufacturing industry may be illustrated by citing a single instance of the dependence of Seattle upon out-

side sources to supply the needs of its people. In this city of 300,000 population, during the past year, 7,207 cars of vegetables and fruits were shipped into the city. This is equivalent to a carload for every seven families. Of three million packages making up the total receipt, a million and a quarter came from outside the state. Four transcontinental railway lines and sixty-four water lines enter Seattle and bring their cargoes for distribution.

In conclusion, if one looks forward with prophetic vision to the industrial development he will see a great dairy industry centered in the humid regions of Puget Sound and the Coast; a great diversified farming industry; fruit and grain growing in the central and eastern portions of the state; and factories with their multitudes of workers utilizing nature's stores and harnessing the latent power of her wonderful mountain streams.

The Mineral Resources are treated in a special article, p. 343.

THE SPOKANE COUNTRY; ITS INDUSTRIES AND CITIES

By J. E. Buchanan

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THE Spokane Country in Washington is that portion of the state east of the Cascade Mountains. It includes topographically the Columbia Lava Plateau, the Okanogan Highland in the north and the Blue Mountains in the south-east. Here we have the noted wheat sections, the Big Bend and the Palouse, the general farming area in the southern part known as the Walla Walla country, and the fruit sections, the Yakima and Wenatchee Valleys in the western part.

The Spokane Country was pronounced by early travelers as a "region unfit to be the home of civilized man." Now nearly one-half million people inhabit the portion of the Spokane Country which is in Washington alone. In this region we find some of the richest and most productive agricultural land in the United States.

History

The early travelers already mentioned, based their opinion on the apparent worthlessness of the area and the seemingly light rainfall. In 1853, General Stevens stated that there were several "stretches of eastern Washington which invited settlement." The discovery of gold in the region in 1855 attracted attention. The military settlement of 1856 near the Whitman settlement of 1836 in Walla Walla County included a few settlers. Walla Walla County had 1300 white people in 1860.

In 1858, Spokane County was created by the territorial legislature. It included all land west of the Rocky Mountains, east of the Columbia River and north of the Snake River. The admission of Oregon as a state in

1860 left all of south Idaho, and parts of western Montana and Wyoming in Spokane County.

The Spokane County so defined was abolished in 1864 and the territory was annexed to Stevens County. This held until 1879 when it was again formed and the county seat was temporarily located at Spokane Falls which in 1887 was made the permanent county seat.

Power

Eastern Washington has a great deal of water power of which the larger portion is undeveloped. One of the best developed areas is that of the Spokane River which drains an area of roughly 6,000 square miles, but nearly three-fourths of it is in Idaho. The area reaches to the Bitter Root Mountains and includes all of the tributaries of Lake Coeur d'Alene for it is this lake that has for its outlet, the Spokane River. In a distance of 100 miles Spokane River has a fall of 1280 feet, 130 feet of this being in the city of Spokane; the power has been developed by the Washington Water Power Company. They have fully developed 87,000 horsepower, have developed but not fully equipped 33,000 horsepower and have 25,000 horsepower entirely undeveloped making in all 145,000 horsepower from this river. This power is used in the city of Spokane for electric railways, lighting, and furnishing power to a large number of factories. The company also furnishes power to cities and towns in a radius of 75 to 100 miles in the Inland Empire. The power stations of the company are located at Little Falls and Long Lake, not very far from the mouth of the river, at Spokane, and at Post Falls near Coeur d'Alene city.

Other important projects which have great possibilities in water power production are (1) that of the Pend Oreille River where a maximum estimate of 350,000 horsepower is made, (2) in Chelan County, an equal estimate of horsepower from the Chelan River, Entiat River, and Columbia River, (3) in Franklin County from the Snake and Columbia rivers. The Priest rapids in the Columbia River have possibilities of nearly half a million horsepower.

Industries

Cereal Production.—In a report made by R. D. Jarboe, chief grain inspector of this state, practically everyone of the twenty counties of Eastern Washington is mentioned as having a wheat yield for the past year. In this report of Washington's 50,000,000-bushel wheat crop, he states that "not only has it proved the largest, but of good quality—contrasted with the badly damaged conditions of the grain crop in almost every section of the United States."

A remarkable feature of wheat production in this state is its small fluctuation from year to year in total yield.

The Total Wheat Production

1909	40,000,000 bu.	1913	53,000,000 bu.
1910	35,000,000 bu.	1914	41,000,000 bu.
1911	50,000,000 bu.	1915	50,000,000 bu.
1912	53,000,000 bu.		

The data for 1915 are from the report made by Mr. Jarboe, the others from the year book of the Department of Agriculture.

The ten year average yield per acre for winter wheat is 26.1 bushels, and for summer wheat is 19.6. These yields lead any of the other important wheat producing states.

Grain Growing Regions

The first important grain producing area is the Palouse country centering in Whitman County. This county alone in 1915 produced over 11,000,000 bushels of wheat and 4,000,000 bushels of oats and barley. The yield of winter wheat in this section is from 30 to 60 bushels per acre. The rainfall ranges in this county from 21.03 inches on the east side to 17.22 inches in the west. The soil is eolian and is a very fine basaltic loam. Spokane County north of Whitman County with similar conditions of soil and rainfall produces 2,000,000 bushels of wheat.

A much larger area is that known as the Big Bend which includes that portion south and east of the Columbia River in the bend of that river. This area contains the counties of Lincoln, Adams, Grant, and Douglas and altogether produced 20,000,000 bushels of wheat this year. Franklin County bordering the section on the south added another million bushels to the total production of the state. Comparatively a large area is included in the Big Bend region, nearly one-sixth of the area of the state, yet the yield per acre is not large on account of the light rainfall. The rainfall in the northern and eastern part of the belt is slightly above 15 inches but in the southern portion, it is less than 10 inches.

Another area south of the Snake River including the counties of Walla Walla, Columbia, Garfield, and Asotin, although only two-fifths the area of the Big Bend, last year produced 10,000,000 bushels of grain. The soil in certain parts resembles that of the Palouse and the rainfall is about the same.

Fruit Production.—There are several irrigated areas that have national reputation for the fruit produced. One of these areas is in Chelan County where practically 35,000 acres are planted to apples; another section, Yakima County, shipped in 1914 over three million boxes of apples, one-half million boxes of pears, and one million boxes of peaches. Other fruit areas are found in Spokane, Okanogan, and Walla Walla counties. Benton County is noted for its small fruit.

Cities

Spokane, population, 1910, 104,402; U. S. Census bureau estimate in 1915, 142,190, has had a phenomenal growth. The first settlement was made in 1870. The population in a little more than ten years had grown to 1500 and in twenty years was 20,000. The city in 1889 was visited by a fire that destroyed thirty-two blocks in the heart of the city.

A recent writer gives the cause for Spokane's development as the falls and the wheat production in the Palouse and Big Bend. To these two causes must undoubtedly be added a third, namely its position in reference to natural routes for railroads to the coast. Spokane is truly the entrance to the state from the east. Two natural ways for approach are possible and are used. One is on the north by the way of Clarks fork of the Columbia, Lake Pend Oreille and then across to the Spokane River. This route is used by the Northern Pacific railroad. Another route is by the way of the Kootenai River, thence to Lake Pend Oreille and to the little Spokane River; used by the Great Northern. Other roads, namely the O. W. R. R. and N. Co., and Chicago, Milwaukee and St. Paul enter by way of tributaries of the Spokane River to Lake Coeur d'Alene. With one exception the transcontinental lines leave Spokane going westward by way of Hangman (Latah) creek and Marshal canyon by way of Cheney. In a distance of sixteen miles an ascent of 400 feet is made and the railroads reach the plateau where the elevation is near 2400 feet.

The transportation facilities of Spokane are excellent. In addition to the five transcontinental lines, there are important branch lines radiating to all parts of the Inland Empire. There are also two electric lines having an interurban system of 213 miles.

The following quotation from a letter received from the Industrial Department of the Chamber of Commerce of Spokane indicates the importance of Spokane industrially: "A careful estimate placed on the amount of the freight bills is $1,385,000 monthly; this makes a total of $16,620,000 per year. Freight charges probably represent on an average 30 to 35 per cent of the value of the goods, so that on a 30 per cent basis, the value of these shipments would be $55,400,000. We have three flour mills here, the Centennial Flour Mill, the Spokane Flour Mill and the Portland Flour Mill. The combined output would be approximately 550,000 barrels per year while the Centennial Mill makes in addition a line of cereals, the output of which would probably run 120,000 barrels per year. Of the many saw mills in this country we have only two in Spokane. We do not have any figures on those outside, but the Phoenix Lumber Co. of this city has an output of approximately $450,000 per year while the McGoldrick Lumber Company's output is about $500,000 per year. We have in all lines about 250 manufacturing firms in this city. The capital invested, including the public service corporations, is $50,926,000. The number of operatives is about 10,000, the annual wage, $8,104,174 and the annual products of these factories about $50,000,000. One of our factories of which we are particularly proud is the Inland

Empire Paper Mill. This concern was established here about four years ago and its total output for the first year was $150,000. During the past year, its payroll was $150,000 and the output was over $1,200,000. They are shipping their products over a wide territory; in fact, all of the states of the northwest, as far east as Montana and Utah and as far south as Los Angeles, California. In addition they are doing some exporting to the Hawaiian Islands."

Walla Walla, 19,364 in 1910; U. S. estimate, 1915, 24,205, is located in an area noted for its general farming produce. It lies south of the Snake River and includes some of the best farms of the state. The commercial club furnishes the following data of produce shipped from Walla Walla during 1915:

Onions	200,000 sacks
Asparagus	250 tons
Rhubarb	500 tons
Beans	100 tons
Cabbage	500 tons
Green Peas	50 tons
Tomatoes	100 tons

Potatoes, carrots, spinach, and other garden stuff to the value of approximately $100,000. This does not include the grain received in the city warehouses. Manufacturing amounts annually to $3,000,000. Whitman College, one of the older educational institutions of the state is located here.

North Yakima, (14,082; 1915, 19,844). Located on the Yakima River, it is the center of an important irrigated section of the state. It has good railway facilities being served by the Northern Pacific and the Oregon-Washington lines. It has several important manufacturing plants among them being flour mills, creameries and lumber products mills. The Washington State Agricultural fair is held here annually.

Ellensburg, 4,209, a city northwest of North Yakima on the Yakima River, is also surrounded by a large acreage of irrigated land. It is located on the main lines of the Northern Pacific and the Chicago, Milwaukee and St. Paul railroads. Several creameries, two flour mills and a number of other enterprises make it an important city. One of the state normal schools is located at Ellensburg.

Wenatchee, 4,050, is located on the west side of the Columbia River at the mouth of the Wenatchee which furnishes an abundant supply of water for irrigation. The city and surrounding country is all one vast orchard broken up into ten and twenty acre tracts. It is the largest city on the Great Northern Line between Spokane and the coast. It is also the junction of branch lines north and northeast and is the lower point of boat service on this portion of the Columbia.

Colfax, 2783, is the county seat of Whitman County in the heart of the Palouse. On account of the topography surrounding Colfax it is not an im-

portant shipping point for wheat in the county. It is the terminal of the Spokane and Inland Empire electric line and is also on the main line of the Oregon-Washington Railroad and Navigation Co.

Pullman, 2,602, located also in the Palouse is noted most of all as the home of the Washington State College and is one of the pleasant home cities of the state. It is surrounded by a rich agricultural region.

Dayton, 2,389, is in the southern part of the state in a county noted for its cereal production. Columbia and Garfield counties produce more barley than any other section of the state. Nearly a million bushels of grain are marketed at Dayton annually.

Pasco, 2,083, near the mouth of the Snake River on the Columbia, is an important transportation center. It is a railroad center and has also excellent steamboat service since the completion of the Celilo Canal. Through this it has cheap transportation rates for an inland city.

Ritzville, 1,859, is the leading grain market in Adams County, a county that ranks third in wheat production in the state. A large flouring mill of 450 barrels daily capacity, furnishes its products to Europe and the Orient and justifies Ritzville's slogan, "The Bread Basket of the World."

Tekoa, 1,694, in the Palouse country is a thriving wheat market and railway center.

Pomeroy, 1,605, is the county seat of Garfield County and one of the principal shipping points for wheat and barley in the state.

Palouse, 1,549, on the Palouse River, is a trading center for a large section. It is provided with two flour mills and a creamery.

Colville, 1,512, county seat of Stevens County, a rich agricultural section, is located in a wide portion of the Colville River valley. The county has several good mines in operation, has large deposits of marble and a large amount of standing timber.

Prosser, 1,298, and *Kennewick,* 1,219, the leading centers in Benton County, are surrounded by a large acreage of irrigated land. The strawberry crop in 1915 netted the county $10,000,000.

Davenport, 1,229, county seat of Lincoln County in the Big Bend is the center of wheat shipping in this county that ranks second in importance in the state.

FIELD COURSE IN GLACIER AND YELLOWSTONE PARKS

Professor E. J. Saunders of the Department of Geology of the University of Washington will conduct a geological field course in the above named National Parks from June 19 to July 28. The party will be limited to 30. Cost $150 to $180. For particulars address Professor Saunders. An excellent opportunity to combine pleasure, recreation and the most effective kind of geological instruction.

SOME GEOGRAPHIC INFLUENCES OF EASTERN WASHINGTON IN RELATION TO AGRICULTURE

By H. J. Lechner

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THE generally accepted idea that Washington comprises two distinct geographic sections is only relatively true. The geographic differences in Eastern Washington, especially as they affect agriculture, are about as marked in some cases as between the two main parts of the state. Rainfall and soil are the important influences, but altitude and topography too help to determine the products of different sections. In Kittitas Valley, sometimes known as the Upper Yakima, we are told that the higher altitude in comparison to Yakima will ever keep fruit-growing from being of first importance as an industry. However, the wide variation in the soil and subsoil and the less intensive irrigation have an important influence in preventing extensive reduction in size of farms and hence keeping out the possibility of extensive small orchard tract planting. The Kittitas Valley timothy hay is of first quality because of uniformly good weather for curing, and not because of soil adaptation. Yakima Valley proper produces larger quantities of hay (alfalfa), but the difference in soil, the lower altitude, the more intensive irrigation all have an influence in making this primarily a fruit section.

Experience has shown, however, that in some localities here topography has had its influence in an agricultural adjustment by eliminating fruit growing in the lower levels subject to alkali, and to confine peach growing to areas with a better air drainage and not so subject to low spring temperatures. Lower Yakima Valley, the major portion of which is Benton County, differs agriculturally from the other parts of this Valley because of the lower altitude, and because of the coarse sandy soil,—these two also causing a higher average annual temperature. These are the influences which put Kennewick in position to claim the earliest strawberries in the state. The coarse sandy soil warms up quickly, hence the early start of this crop. In this county too we can, because of the relatively high air and soil temperatures, easily believe the great possibilities in growing corn which have already been fully demonstrated. The type of soil and the winds also have resulted in some adjustment among farmers who have learned by experience the losses resulting from blowing soils where large areas of uncultivated ground are left exposed. Alternating narrow fields of alfalfa and cultivated crops are an illustration of how this has been overcome in a great measure. The entire Yakima, the Wenatchee, and Spokane valleys produce the major part of Washington's ten to eleven million dollar apple crop. Walla Walla County, and small sections on the Snake and Columbia rivers produce most of the remainder. The many sunshiny days of the growing season throughout these sections are the important factor, causing the rich coloring that is so predominant in the state's apple crop. The low cost of producing roughage, the hay prices, and

high prices of dairy products have all caused an increase in dairying through the irrigated districts.

The wheat producing area, largely because of differences in rainfall, comprises two rather distinct types of grain farming. In the Big Bend country parts of Benton, Klickitat, and Walla Walla counties and the higher lands of the irrigated districts that can not be watered, and where the rainfall usually does not exceed 16 inches, crops can be grown only on alternate years. In the other years the land is left fallow, first to save moisture for the following crop; second, to kill weeds; third, to store up plant food. Careful observation of the dry land farming experts show that even with the best methods of tillage only 70 per cent of the 12 to 15 inches of rainfall in typical areas of the Big Bend can be made to enter the soil. By clean and careful summer fallowing 80 per cent of this will still be in the soil the next fall. On this basis about 7 inches of rainfall is in the soil at fall seeding time, or 14 inches for the two years. As no crop can use all moisture present we do not have more than 12 or 13 inches in this region to be used by the wheat. Observations have also shown that each of these 12 to 13 inches will produce about 2.5 bushels of grain, making a possible yield of 30 bushels per acre under proper methods. This is even excelled by some of the best farms in the Big Bend country. It is here that our wheat farmers best heed agricultural teaching, for they realize that the difference between careful and careless work means the difference between success and failure. Here, as throughout the entire wheat section, the possibilities of high yield lie fundamentally not merely in the quality of the soil, but in its high moisture holding capacity, and the fact that the rainfall comes in the late fall, the winter, and early spring season.

The middle western farmer has had to learn dry farming a second time when he came to grow wheat in Washington, because here, with winter season precipitation, the soil must be fall-plowed and made receptive to this moisture, while in the middle west a large part of the moisture supply comes in the growing season. In the Palouse country and southwestern Washington fall plowing is doubly necessary, because of the heavier rains and the very rolling character of the land. It is not difficult to see, then, that Washington dry-land farming methods are an effort, by the best known means, to adjust agriculture to geographic influences peculiar to the state. In some cases these efforts fail, due to a soil that does not hold moisture, especially when the season is unusually windy. That is mainly why even the best methods sometimes fail, with seemingly small differences in rainfall and wind. The soil, poor in power to hold and store moisture, as well as the low rainfall (below 10 inches) both are influences determining the limits of areas fit for wheat production.

In the Palouse Country, constituting mainly the southern part of Spokane and all of Whitman counties, and southwestern Washington, the area south of the Snake River and east of the low rainfall belt at Pasco, the additional rainfall and difference in soil are responsible for methods of farm-

ing used here. Scientific agriculture has shown that some crops can be raised in this section every year, and hence the introduction of corn, field peas, and other crops, and therefore also an increase in livestock production. Both in moisture holding capacity and in natural fertility this soil is unexcelled. Maintaining a high state of wheat production means careful saving of moisture (but not from one year to another, as in the Big Bend), keeping down weeds, and raising of crops as adjuncts to wheat farming which will keep up fertility. Little land needs to be left idle, primarily because of the additional 6 to 8 inches rainfall. Therefore, farming is more profitable and land values higher.

Weather conditions and topography are also important influences determining harvesting methods. Whereas in southwestern Washington the binder is hardly seen, it predominates in the northern Palouse region. Here the binder seems necessary because of the presence of dews in harvest time and of the less uniform ripening. Never, as is the case farther south in the state, do we find "from header to thresher" harvesting. Headed grain is stacked here. The greater use of the combined harvester in the more level areas is due to the necessity of keeping the speed of the machine as uniform as possible. However, this difficulty has been partly overcome by running the machinery by different power than that which draws it over the fields. While important local influences of climate and soil determine adaptation of varieties and types of wheat, nowhere in the United States are the non-shattering club wheats so popular. This characteristic is so essential here because the climate makes it possible for farmers ot allow wheat to stand in the field long after it is dead ripe, and therefore to harvest greater areas with the same equipment.

The eastern Washington counties bordering Canada (sometimes known as the Okanogan Highlands) comprise comparatively little in the way of developed agriculture, except in the line of stock raising. Topography has its influence in making agriculture here rather varied. Even in the small irrigated valleys farming is more diversified. The development of natural resources, better communications, and the settling up of large areas of land still to be taken, will have their influence on agriculture in this region.

Thirteen counties in eastern Washington, in districts designated as the Big Bend, the Palouse and the Walla Walla, west and south of the city of Spokane, produced, in 1909, a crop of 35,095,000 bushels of wheat, 6,000,000 bushels of oats and 4,500,000 bushels of barley, besides several million dollars' worth of fruits, vegetables and grasses. Whitman and Lincoln counties led all in the area devoted to grain, producing 16,500,000 bushels of wheat, of which 8,500,000 is credited to Whitman county, which also has first place with 3,000,000 bushels of oats.

THE PORT OF PUGET SOUND

By Albert C. Herre

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SEATTLE

THE Port of Puget Sound, which includes all the cities around the Sound, surpasses all other Pacific Coast ports of the United States in the volume of its commerce, ranking next after New York, New Orleans, Boston, Philadelphia, and Galveston, in the order named. This is due not merely to the immense quantity of foreign and domestic goods which naturally passes through the cities of Seattle and Tacoma, en route to the Orient or the eastern states, but to their peculiar advantages over some of the cities now ranking higher in the above list. Nearly all the cities included in the Port possesses not only great natural and agricultural resources, as yet but partially developed, but these are allied with large and rapidly increasing manufacturing interests. This last is made possible not only by the extensive neighboring coal fields and cheap fuel oil from California, but more especially by the utilization of the adjacent mountain torrents and waterfalls for the development of electric power. This is here produced in such quantity and at so low a cost as to rival any region in the world for cheapness. As yet, this resource is only beginning to be developed. Combined with the wonderful harbor facilities and nearness to the Orient, and the admirable transcontinental railway connections, the conditions are almost ideal for the development of one of the world's greatest seaports.

Imports.—Silk worth $44,000,000, mostly in the raw stage, passed through the Port of Puget Sound in 1915, most of this through Seattle, which city is easily the leader of the cities of the Port district, not only in volume of imports and exports, but in domestic trade, manufacture, and finance. Tea, nearly $5,000,000 worth in 1915, hemp from the Philippines, jute from India, rubber from the Straits Settlements and the Malay Peninsula, peanuts, copra, and curios are among the leading imports.

The local exports of greatest value are lumber and lumber products, canned salmon, condensed milk, wheat and flour, and fruit, especially apples. Wheat, which comes not only from eastern Washington, but from Idaho and Montana, is shipped to Japan when wheat is cheap, but more and more the manufacture of flour increases in Seattle, while the proportion of wheat exported decreases. Seattle itself produces no canned salmon or condensed milk, but as the financial and trade center of the state does an enormous business in these commodities, which go to all parts of the world. In 1914, 144,000 tons of canned salmon were handled in Seattle, while the trade in fresh halibut, herring, codfish, and salmon amounted to 27,000 tons. There is also a vast tonnage of cotton, steel and iron products, machinery, and general merchandise trans-shipped through Seattle from the southern and eastern states to the Orient.

The domestic coastwise trade is very extensive, but is especially large with Alaska, which draws her supplies of all kinds from Seattle, sending in return her salmon, furs, and gold. With the permanent opening of the Panama Canal, the coastwise trade with Atlantic Coast domestic ports will grow by leaps and bounds.

One factor, soon to be available, of great importance to Seattle as a shipping center, is the presence of Lakes Union and Washington. A ship canal is now in construction and within a few months the largest ocean going vessels may anchor in Lake Washington, where the coat of barnacles on the ships' bottoms may be removed at small expense, fresh water being fatal to these animals. The canal to Lake Washington is being built by the United States Government and King County, Washington, at a cost of $3,625,000. The canal has one large lock and one smaller one, the former being the largest ever built on this continent, except the locks in the Panama Canal. The shore line, suitable for docks along the lakes and the present harbor is sufficient to afford ample room for all time to come.

Manufacturing.—The most important single manufacturing industry of Seattle, employing more men than any other, is the building of ships and vessels of all kinds, from a row boat to a battleship or submarine. Associated with the ship yards are the largest rope walk and dry docks on the Pacific Coast, and many large foundries, machine shops, and other metal working establishments turning out a great variety of products. Saw mills and shingle mills, sash and door factories, box factories, and other manufactures of lumber products, add much to the wealth of the city though not so important relatively in Seattle as in some other cities of the region. Here are the largest clay products plants, manufacturing jewelry plants, and shoe factory west of St. Louis, and an immense factory for making the tin cans necessary for the salmon and milk industries.

While Seattle is second among the cities of Washington in the manufacture of flour, she has the largest flour mill in the state, and with the completion of the additions now under construction will lead the state, her mills then having a daily capacity of 9,800 barrels.

The estimated population of Seattle in 1915, according to the United States Census Bureau, was over 330,000.

Tacoma

Like the other cities of the Puget Sound region, Tacoma is the outlet of a district having vast agricultural, forest, mineral, and fishing resources, and in addition is unsurpassed in harbor facilities and in possibilities as a manufacturing center. More than 100,000 horse power of electric energy is now available from the great hydro-electric plants which harness the melting-snow waters of the Cascades; it is believed that this can easily be increased to 1,000,000 horse power, affording cheap power for an incredibly great development of Tacoma as an industrial city.

Tacoma is the chief outlet for the great wheat district of the Inland Empire, and is the largest wheat shipping and flour milling point west of Minneapolis. Her mills have a daily capacity of 9,500 barrels.

Manufactures.—The value of Tacoma's annual output of flour and cereal products is $8,000,000. The leading manufacturing industry is that of lumber and other wood products to an annual value of $10,000,000. Dressed meat and packing house products are valued at $5,000,000 annually; the largest car shops in the northwest are maintained here by the Northern Pacific company, and car wheel shops, machine shops, foundries, and iron works are among the city's industries. The plant having the most valuable product and certainly the one appealing most to the imagination is the great smelter, the largest west of Butte, Montana. Here are treated silver, lead, and other ores from all the states of the west and northwest, copper ores from Alaska and Peru, tin ores from Bolivia, Malaysia, and Alaska, and gold and silver concentrates from nearly all regions bordering the Pacific. The European war is responsible for the diversion of some of these South American ores from Wales to Tacoma, but it is believed that with the development of tin mines in Alaska a great tin smelting and tin-plate industry will grow up here which will permanently hold the purifying of Bolivian tin. In 1911 the value of the smelter output was $11,709,000; since that time the smelter has been enlarged and its product is worth proportionately more.

From the Orient Tacoma receives silk, tea, matting, curios, peanuts, camphor, porcelain, jute, hemp, spices, and a vast miscelaneous list of commodities, while in return she sends in addition to the Washington exports already named, much raw cotton, machinery, and general merchandise.

A large ocean traffic is also carried on with Alaska, California, South America, and European ports. The total export business for 1911 was valued at $25,899,628, while the total import business amounted to $21,566,089. At the present time the volume of business is much greater but exact figures are not available.

The estimated population of Tacoma, July 1, 1915, was 104,000.

The shipping facilities of Washington, with its 2000 miles of shoreline, its great inland sea, and about 1000 miles of navigable rivers, are unsurpassed anywhere. Different lines of freight and passenger vessels connect all the larger ports of the Pacific with the railroad terminals on Puget Sound, Grays Harbor, and Columbia River. In addition to Washington products shipped from these ports, cotton, steel rails and many other articles are brought from the east and south by rail and are shipped to the different Pacific ports in return for rice, silk, hemp, fruits, and all kinds of merchandise not grown or manufactured in our own country. Hundreds of small boats ply on the waters of Puget Sound, and the various rivers, handling freight and passengers from more than 200 ports on these waters.

CITIES OF NORTHERN PUGET SOUND

By M. Inez Termaat

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Bellingham

BELLINGHAM (24,300 in 1910, present estimate 33,800), enjoys an unrivalled scenic location at the head of Bellingham Bay, a northern arm of Puget Sound. Four early trading and coal-mining towns situated around the bay finally coalesced to form the present city. The principal streets, one above another on the sea-facing slope of Sehome Hill, follow the curving outline of the shore. The homes on the heights command a view of the business section of the city, of the Cascades and snow-capped Mount Baker to the north and east, of the San Juan Islands and the Olympic Mountains to the west and south.

Due to the prevailing westerly winds off the Pacific Ocean, there are no seasonal extremes of heat and cold, the mean annual range of temperature being from 39° to 61.6°. The average annual rainfall is only 30.5 inches, the heavy precipitation usually attributed to this section being intercepted by the Olympic Mountains and Vancouver Island.

The Nooksack River, turbulently sourced in the mountains, has in its lower reaches built a broad, flat valley where dairy herds live in clover the year round. The soil is a rich silt loam very encouraging to truck gardening and flower culture, both of which have become important. Poultry raising is also an important industry in this valley. This large farming district is connected with the city by miles of well paved roads.

The largest salmon canning industry of the world is centered at Bellingham, the output amounting to millions of cases yearly. There are six lumber mills using the Douglas fir from the mountains, thirteen shingle mills utilizing the cedar, nine wood-working industries, two foundries, a mattress factory, a modern cement plant, several fruit canneries, brick and tile works, and boiler works. In 1911 the total value of manufactures exceeded $7,000,000.

In 1907 a United States experiment bulb farm was established just outside the city where Holland tulips have bloomed ten days earlier than in their native land. Hyacinths and Narcissus thrive exceptionally well in this climate.

Transportation facilities are such as to make Bellingham an important commercial center. The harbor is deep and large. There are three miles of wharfage where ships from all parts of the world take on cargoes of lumber, shingles, cement, and canned goods. Two boats daily connect with Seattle, and others with various points on the Sound. Four railroads and an electric interurban give sixty-one trains daily. The Pacific Highway, a coastwise automobile road connects Bellingham with all the coast cities. The largest of three state normal schools is located in Bellingham.

Everett

Everett, the "City of Smokestacks," had in 1910 a population of 24,814, an increase of 216 per cent during the decade. The present local estimate is 30,000. It is advantageously situated on Puget Sound thirty-five miles from Seattle and about one hundred and fifty miles from the Pacific Ocean. It has twenty-two miles of deep water frontage with about three miles of wharfage including three deep-water docks. Everett is a port of call for some vessels plying between San Francisco and Alaska. Five steamers run daily to Seattle and one to Bellingham, while vessels from many parts of the world receive cargoes here. Four railroads give coastwise transportation service, and it is the first coast terminal of the Great Northern Railroad.

Along the water front are located many manufacturing concerns, the chief products of which (lumber, machines, and paper) are marketed throughout the world. The only arsenic plant in the United States is located here. There are two flour mills, a powder factory, a tannery, a brickyard, fish canneries and shipyards. The total annual payroll of its ninety manufacturing plants exceeds $4,000,000.

In climate Everett shares with other Puget Sound cities the ameliorated conditions obtaining on western coasts of all continents where westerly winds prevail. The annual rainfall is 37 inches, the larger per cent of which occurs between October and April though occasional rains relieve the "dry" season.

Smaller Cities

Anacortes, population, 1910 census, 4168. Beautifully located on Fidalgo Island, a few hours by steamboat north of Seattle. It is an important seaport and is reached by the Great Northern railway. Its principal industries are lumbering and fishing, but it is surrounded by country adapted to diversified farming. There are nine shingle mills, two glue and fertilizer factories, six salmon canneries, two codfish plants. The total monthly payroll is $100,000.

Mount Vernon, population, 1910 census, 2381, is located eight miles from Puget Sound on the navigable Skagit River from whose yearly floods it is protected by dikes. This town is important for its dairy industries including two large condensaries.

Blaine, population, 1910 census, 2289, is interesting as the most northwesterly municipality in continental United States. It is situated at the boundary line of British Columbia on Drayton Harbor. Its industries consist of salmon canneries, crab cannery, saw mills, box factory, lacquer factory, shingle mills and machine shops. Oysters are cultivated in the harbor.

CITIES OF SOUTHWESTERN WASHINGTON

Aberdeen (13,660) and *Hoquiam* (8,171) are located on Grays Harbor in the center of one of the best timber districts of the state. The industries of

both cities at present depend on the timber supply and the harbor facilities, but as the timber is removed the land will be used for agricultural purposes and other industries will take the place of the lumber industry. Ships from all sections of the world load lumber directly from the large saw mills located here.

Vancouver (9,300), one of the oldest towns in the state, is located on the Columbia River where the main lines of the north and south railroads cross the river by bridge into Oregon. It is the center of a fine fruit growing and agricultural district. One of the oldest army posts on the coast is located here.

Centralia (7,311) and *Chehalis* (5,000) are located on the main railroad lines between Tacoma and Portland in a broad open country well adapted for agricultural development. With an annual rainfall of 46 inches, and a range of temperature between 40° and 61°, pasturage is good the year round, and much of the logged-off lands may profitably be used for dairying.

Olympia (7,000), the capital of the state, is located at the head of Budd Inlet, a long southern arm of Puget Sound. On the tide flats around the bay large areas are used for oyster beds. It is in the center of an important agricultural country formerly better known as a lumbering district. Tumwater falls on the Deschutes River, about which one of the oldest settlements north of the Columbia River was started, furnishes electric power for the city and the surrounding district. It has a very good harbor, but is too far from the Pacific and off the main transportation lines to be considered with the northern ports on the Sound.

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